ECONOMIC BOTANY

DEVOTED TO APPLIED BOTANY AND PLANT UTILIZATION

News of The Society for Economic Botany

Yareta—Fuel Umbellifer of the Andean Puna — W. H. Hodge

The Emblic (Phyllanthus emblica L.) — Julia F. Morton

Processing of Pistachio Nuts — Felix Bloch and John E. Brekke

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ECONOMIC BOTANY

Devoted to Applied Botany and Plant Utilization

Founded by Edmund H. Fulling

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Editorial Statement

Although the new editorial organization of The Society for Economic Botany was appointed late in 1959, it is only with this, the second number of volume 14, that it assumes its full responsibility for the publication of ECONOMIC BOTANY. By the end of this volume it expects to be a smoothly functioning organization with a regular publication schedule. Until then it requests the patience of its loyal subscribers; and invites their support in providing manuscripts.

News of
THE SOCIETY FOR ECONOMIC BOTANY

At the AAAS meetings in Chicago in December, 1959, one of our charter members, Dr. Charles M. Rick, University of California at Davis, received the Campbell Award for Vegetable Research established by the Campbell Soup Company. The award included a bronze medal and $1500. Dr. Rick's studies on the cytogenetics and evolution of both wild and cultivated forms of the tomato were the basis for the award. His paper published in Economic Botany (**12**(4): 346-367. 1958) was part of the outstanding contribution for which the award was made.

On the 21st and 22nd of May the first annual meeting of the Society for Economic Botany was held at Purdue University, Lafayette, Indiana. There was an attendance of between 50 and 60 members at all sessions, and at the annual banquet and business meeting. Dr. E. Guenther, who was appointed President for our first year, was elected President for the coming year. The other officers are Dr. Quentin Jones, Secretary, and Dr. Richard M. Klein, Treasurer; Dr. H. W. Youngken, Jr. is the newly elected Chairman of the Council.

Papers presented at the Symposium on May 22nd will be published in the last number of this volume. Several of the contributed papers read at the other sessions will be published in this and the next volume.

The membership of the Society was well represented both geographically and professionally at this first meeting, and it is with considerable interest and enthusiasm that the second annual meeting is anticipated.

Fig. 1. Typical *puna* in southern Peru at 15,000 ft. elevation. (Photo *W. H. Hodge*)

Yareta—Fuel Umbellifer of the Andean Puna

W. H. HODGE[1]

Occupying large areas of the high Andes in southern Peru, the western Bolivian plateau and northern Chile is a cold, bleak desert known as *puna*. In this treeless vegetational zone are to be found strange communities of plants curiously modified for specialized life at high elevations. Various kinds of so-called cushion plants, representing members of several plant families, comprise a characteristic element of the puna flora. In these plants the aerial portions—branches and leaves — are compressed tightly together to form an irregular cushion-like mass, which may rise to as much as a meter in height and four meters in diameter. Such a form, of course, offers a minimum of evaporating surface under the arid puna conditions. Cushion-producing species of the umbelliferous genus *Azorella* (including *A. yareta*, *A. diapensioides*, and perhaps several other similar species) are not only among the most abundant plants, but also represent the most important economic species of the puna, having long served as primary fuel sources for the highland Indians. From the Quechua has come the aboriginal name *yareta* (*llareta*) by which these plants are best known, while to the Aymará the various *Azorella* species are called *timiche*.

The appearance of yareta as it grows under puna conditions is accurately described in the following excerpt from Rusby (1):—

"In crossing the plains of the higher Andes one is likely to encounter a landscape thickly dotted with what appear to be rounded and moss-covered stones, their surfaces of a beautiful dark-green color. What will strike him as peculiar is the fact that other stones, abundant on the intervening surfaces, have no such covering, being of the ordinary shades of gray and brown though often exhibiting a growth of gray lichens . . . examination will show him that the supposed stone is a much condensed shrub, arising from a thick, woody, more or less central root, and having its erect branches and branchlets so tightly crowded together that they have become essentially a loosely solid mass of wood, often exceeding a foot in height and two or three feet in breadth. The result of this habit of growth is the production of a peculiar columnar or crystal-like structure of the mass, which splits very readily, but is decidedly tough in cross-section. In the natural growing position of the plant, none of this woody structure is visible, since the surface is regularly rounded outward and downward, until it meets the very surface of the earth on all sides, so as to resemble a convex green cushion, resting on the ground.

Examining its green surface, we find it to consist of innumerable little branchlets or twigs, about twenty-five to the square inch, or about one-fourth inch in length, and crowded together almost as closely as the cells of a honey-comb. The tip of each twig bears a densely imbricated rosette of minute green leaves, underneath which are the dead remains of those of former seasons. By the annual elongation of these twigs the area at the surface is necessarily increased, with the resulting separation of the twigs from one another, and with decreased compactness of the surface, whereupon the twigs successively branch, thus maintaining the solidity of the mass."

From Rusby's account one should get the idea that in outward appearance the yareta cushion is for all the world like a gigantic irregular cauliflower head and the compacted branches beneath appear like a longitudinal section of that vegetable. So tightly packed is the yareta cushion that a person can actually walk across its hard surface without apparent damage to the plant. In the period of

[1]Longwood Gardens, Kennett Square, Penna.

maximum rainfall in the Andean highlands, January to April, *Azorella* cushions are verdant green, as described by Rusby, but during the longer dry season this color changes to a more earthy shade matching the rocks of the habitat and making it somewhat difficult for the casual observer to differentiate, at least at a distance, between boulder and plant.

Yareta flowers are not showy but are rather insignificant greenish-white, borne in tiny compressed umbels which speckle each cushion during the flowering season. I have noted plants of *Azorella yareta* flowering in southern Peru from May to July. The pale yellow seeds are apparently scattered on the surface of the plant during the last months of the year to be blown by the wind until they reach spots suitable for germination.

Yareta stems and foliage contain a resinous substance which probably aids this plant to conserve stored water under conditions of aridity. The presence of this resinous material is the basis for the utilitarian uses of these plants. In the treeless puna ordinary firewood is absent and yareta has been one of the main sub-

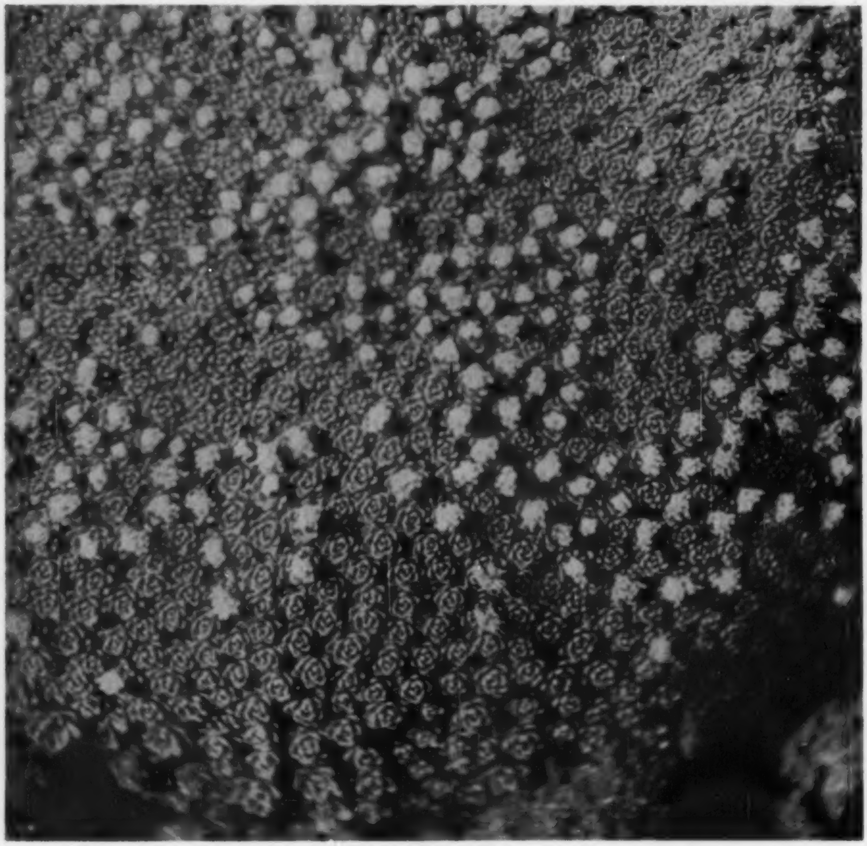

Fig. 2. The convex surface of yareta cushion much enlarged showing crowded mosaics of tiny leaves at branch tips and terminal flowers. (Photo *W. H. Hodge*)

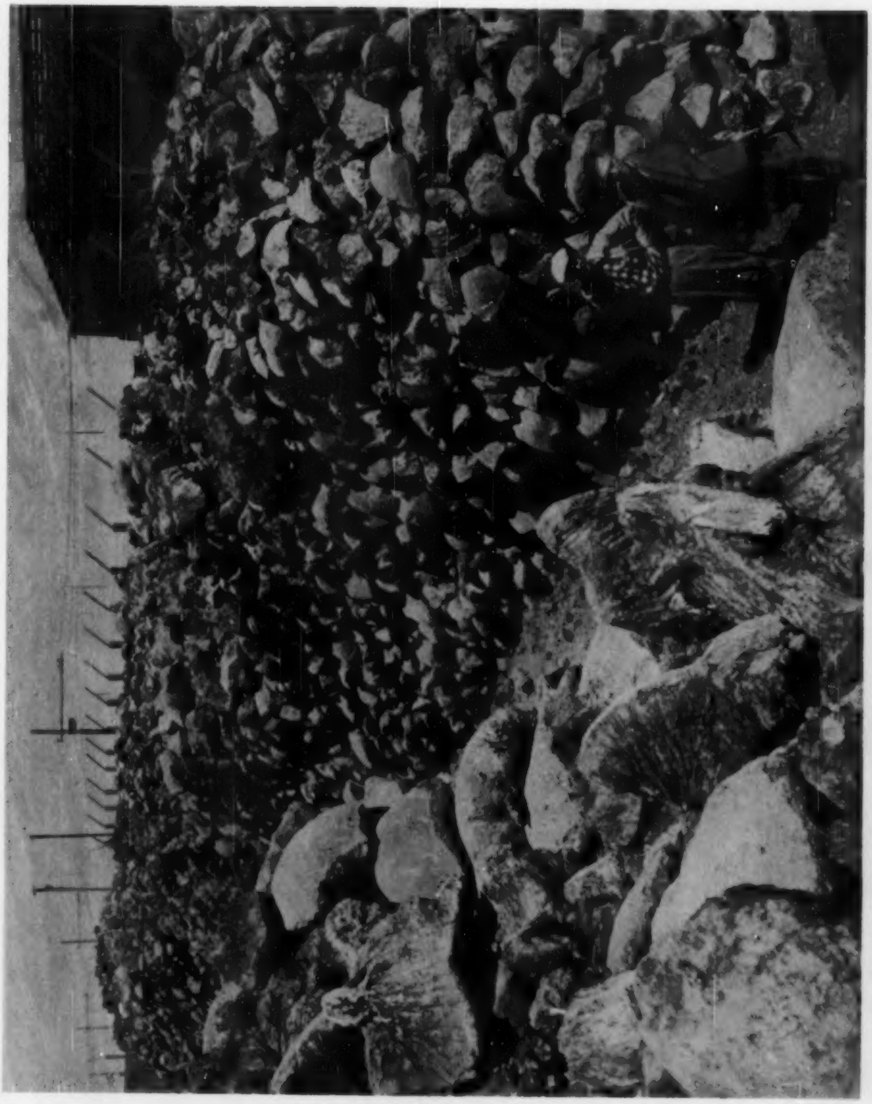

Fig. 3. Piles of dried yareta stored for fuel at Chuquicamata, Chile. Note system of compressed branching stems seen in sectioned yareta plants in left foreground. (Photo courtesy of *H. E. Gardiner*)

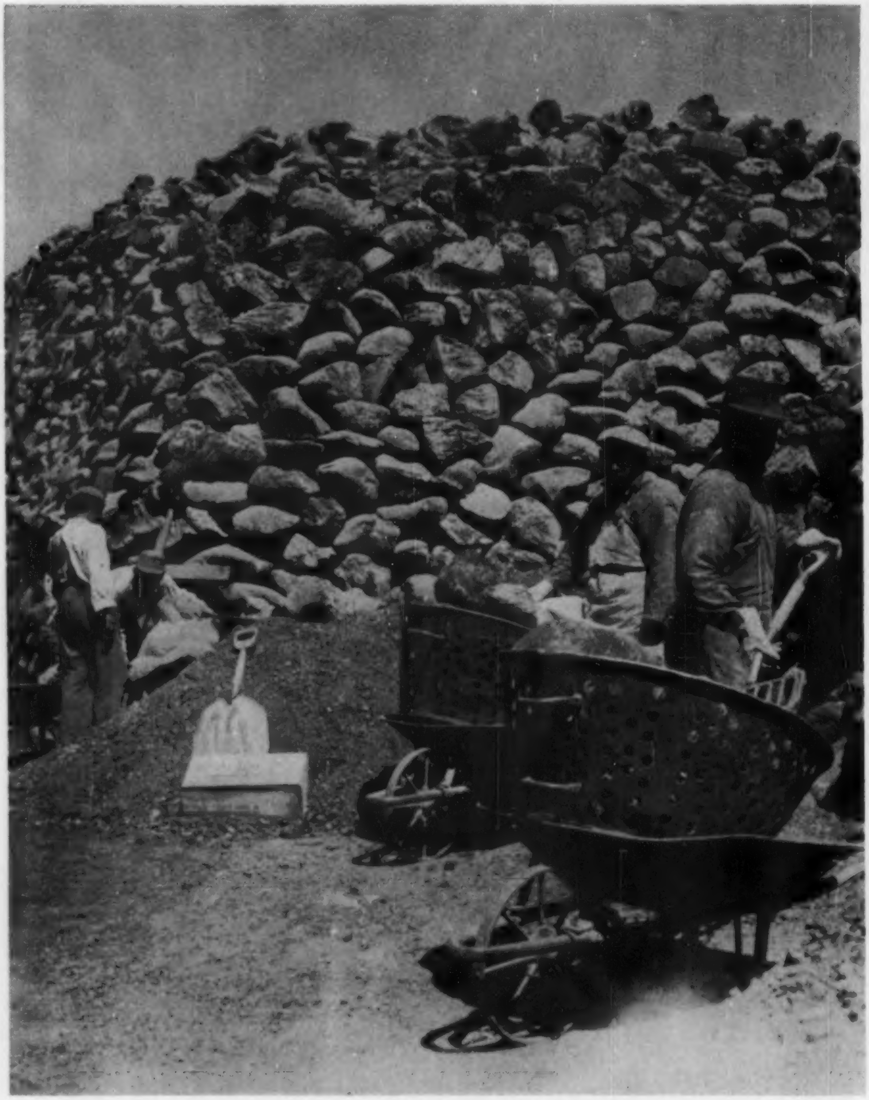

Fig. 4. Handling fuel yareta at Chuquicamata, Chile. Pile of yareta dust (behind shovel in left foreground) is type utilized for making briquette. (Photo courtesy of *H. E. Gardiner*)

stitutes available. It is an excellent pinch-hitter for, when harvested and dried, the resinous material oozes from the cushion making the plant highly combustible. The Quechua and Aymará are also reported to use the resins as astringents and absorbents in their native medicine (2). Indeed, one of the first historical notes about yareta—that of Pedro de Mercado de Peñaloza, reporting in the "Relaciones Geograficas de Indias" from Peru in 1586—refers to this medicinal use in these words (in free translation) "The Spaniards learned about a resin called yareta similar to turpentine and used for treating colds and pains."

Much the more important use of yareta has been as a fuel. The dried cushions when burning evolve an enormous amount of heat with production of little or no smoke. Moreover, this fuel is slow burning and thus can be left unattended when utilized in the home. Yareta has thus been exploited for many years by the inhabitants of the puna, mostly Indian herdsmen, who annually collect their supply of the green cushions several months before needing them, stacking them to dry in piles like cordwood outside their simple huts. The use of this unusual fuel has also been extended to many of the highland villages or Indian settlements and its popularity even spread to industry, especially mines and railroads. For years bakeries in Arequipa, Peru preferred smokeless yareta to other combustibles; and the railroads of southern Peru, Bolivia and northern Chile have utilized yareta as locomotive fuel. Stacks of these plants were, for many years, familiar sights piled high along the tracks at highland railroad stations.

Perhaps more yareta has been used by mines than by any other industry. One

Fig. 5. A good *yaretal* in southern Peru showing cushion-like growth forms of large plants of *Azorella yareta*. (Photo *W. H. Hodge*)

of these is at Chuquicamata, Chile, since 1915 one of the world's greatest copper mines. For a number of years yareta has been a standard sales item in the company stores at Chuquicamata and up to 1958 average sales of yareta at this mine alone were about 1,000 metric tons per month. Principal use has been as a fuel for the homes of workers. Up to 1958 yareta was heavily subsidized by the Chile Exploration Company (which operates Chuquicamata) with the result that the approximate cost of this fuel to workmen was 80¢ (US) per metric ton. In 1958 the subsidy was removed with the result that the ton price increased sharply to $15.26 (US) which closely reflects the actual cost of this commodity delivered in Chuquicamata. As might be expected, yareta consumption dropped immediately from about 1000 to 180 metric tons per month. Even so, the consumption of yareta in Chuquicamata has been declining for some years even though the amount that was purchased in the company stores up to 1958 was substantially the same. This decline is accounted for by modernization of worker's homes resulting in substitution of electricity and bottled gas for yareta as cheaper, cleaner and hence more popular fuels.

Yareta destined for sale at mining towns or in similar establishments is usually obtained from contractors who deal in this commodity in various parts of the high Andes. At points of utilization the fuel is stored in open yards which display thousands of stacked plants in all varieties of shapes and sizes. At Chuquicamata there has even been developed a method of utilizing the yareta dust which had accumulated over the years at the various shipping and storage points. Such dust was combined with fuel oil and coal dust to produce a fairly durable briquette, a fuel with a considerably higher calorific value that the original crude yareta.

As might be expected, *yaretales*—puna especially rich in yareta plants—have been greatly exploited, especially in areas accessible to man. A good *yaretal* has from 10% to 15% of the ground covered with yareta plants or at a rate of about 70 plants per hectare. At the present time the principal and richest area of yaretales is in the western Andean cordilleras where the Chilean-Peruvian-Bolivian frontiers unite. In this yareta heartland *Azorella* plants occur most frequently at elevations running between 4000 and 4800 meters, though yareta also is reported to occur at altitudes of as low as 3800 meters and as high as 5200 meters. There are undoubtedly hundreds of square kilometers of inhospitable or inaccessible puna country where the stands of yareta have been relatively untouched. But for this, this strange, slow-growing cushion plant of the high Andes might by now be threatened with extinction. The introduction of cheaper modern fuels will undoubtedly aid in assuring its preservation.

Acknowledgment

Information on the use of yareta as fuel at Chuquicamata, Chile, has been generously supplied by Mr. H. E. Gardiner of Santiago, Chile, to whom also should go thanks for supplying several photographs.

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2. Yacovleff, E. and F. L. Herrera. "El Mundo Vegetal de los Antiguos Peruanos." Rev. Mus. Nac. (Peru) **4:** 31-102. 1935.

The Emblic (*Phyllanthus emblica* L.)

The emblic is native to tropical southeastern Asia where the fruit is esteemed both fresh and preserved. It is valued as an antiscorbutic and for treating digestive and other disorders. Since the emblic has a highly stable ascorbic acid content, it is considered effective even when dried, powdered, or prepared in the form of candies or tablets. Scientific and industrial institutions in India are developing new products and improved methods of processing this fruit; while Indian horticulturists are active in the propagation of superior varieties. Long neglected in the western hemisphere, the emblic merits further investigation.

JULIA F. MORTON[1]

Introduction

Of more than a hundred species of introduced tropical and subtropical fruits that have been acclimatized in South Florida, none has suffered more neglect than the emblic (*Phyllanthus emblica* L.), which has remained a horticultural stepchild in the western hemisphere for nearly sixty years. In 1901 the United States Department of Agriculture received seeds from the Reasoner Brothers, noted nurserymen and plant importers of Oneco, Florida, with the notation: "This is not the true myrobalan of commerce, although its fruits are used for tanning purposes, according to Talbot. (*Trees, Shrubs and Woody Climbers of the Bombay Presidency,* 2nd ed. p. 300.)" This casual statement and later brief references in Florida plant literature give no hint of the great importance of this species, especially its fruit, in Asiatic diet and medicine.

In 1945 Mr. Claud Horn of the Office of Foreign Agricultural Relations, Washington, D. C., intrigued by Indian reports of the emblic's high vitamin C content, requested that specimens be analyzed at the School of Tropical Medicine of the University of Puerto Rico. Though this was done and good results were obtained, interest quickly shifted to the Barbados cherry, or acerola (*Malpighia glabra* L., or *M. punicifolia* L.),[2] specimens of which were casually brought into the laboratory at that time (3). This more attractive, succulent and already popular West Indian fruit has continued to divert attention from the relatively unappealing emblic, despite subsequent analyses of the latter by Dr. Margaret J. Mustard, of the University of Miami, showing ascorbic acid content as remarkable as that of ripe Barbados cherries (34).

In 1955, the writer, in an effort to promote investigation of the potentialities of the emblic, supplied specimens to Professor Milton Kaplow of the Tropical Food Research Laboratory, University of Miami, Dr. Robert S. Harris, Department of Food Technology, Massachusetts Institute of Technology, and Dr. Juan Navia, Director of the Finlay Institute Laboratory, Havana, Cuba. She also instigated propagating trials at the University of Miami's Experimental Farm (now discontinued) and at the Subtropical Experiment Station of the University of Florida in Homestead; and reviewed the status of the species at the annual meeting of the Florida State Horticultural Society (31). The favorable findings of these investigators, the good growth and hardiness of a row of seedlings set out at the Homestead station, and reports of recent pharmacological and other studies in India warrant reemphasis of the desirability of further exploring the possible

[1]Director, Morton Collectanea, University of Miami, Coral Gables, Fla.

[2]Although these two species have been confused in botanical literature, the Puerto Rican material is said to agree more closely to *M. punicifolia* L. See Kennard & Winters, Some Fruits and Nuts for the Tropics, Misc. Pub. 801, A.R.S., U.S.D.A., p. 83. 1960.

Fig. 1. Heavily laden branches of one of two large emblic trees at Palm Lodge Tropical Grove, Homestead, Fla., photographed in December, 1957. Many fruits had fallen on the ground and some shedding of leaves and branchlets is evident.

utility of the fruit in this hemisphere.

Phyllanthus emblica L. (syn. *Emblica officinalis* Gaertn.) belongs to the family Euphorbiaceae. It bears such local vernacular names as emblic, emblic myrobalan, mirobalano, nelli, amla, aonla, awla, Malacca tree and Indian gooseberry, though the last term is more frequently applied to the related but dissimilar *Phyllanthus acidus* Skeels, a species popularly known as Otaheite gooseberry. The Thai name for the fruit is *makarm pom,* which means "round tamarind" (14).

The emblic tree, native in tropical southeastern Asia, particularly in central and southern India (20), Pakistan, Ceylon, Malaya, China (8), and to the Mascarene Islands (37), normally reaches a height of 60 feet and, in rare instances, 100 feet. While actually deciduous, shedding its branchlets as well as its leaves, it is seldom entirely bare and is therefore often cited as an evergreen. Its fairly smooth bark is a pale grayish-brown and peels off in thin flakes like that of the guava. The miniature, oblong leaves, only ⅛ inch wide and ½ to ¾ inch long, distichously disposed on very slender branchlets, give a misleading impression of finely pinnate foliage. Small, inconspicuous, greenish-yellow flowers are borne in compact clusters in the axils of the lower leaves. Usually, male flowers occur at the lower end of a growing branchlet, with the female flowers above them (6), but occasional trees are dioecious. In Florida, flowering takes place during the summer months; in northern India, during April and May (6); and in Madras the tree blooms in July and again in February, though the second flowering produces only a small crop (35).

The nearly stemless fruit is round, indented at the base, and smooth, though six pale lines, sometimes faintly evident as ridges, extending from the base to the apex, give it the appearance of being divided into six segments or lobes. Light-green at first, the fruit becomes a dull, greenish-yellow or, more rarely, brick-red (35) as it matures. The whole fruit suggests a child's large glass marble; it is hard and unyielding to the touch, and the skin is thin, translucent and adherent to the very crisp, juicy, concolorous flesh. Tightly embedded in the center of the flesh is a slightly hexagonal stone containing six small seeds. Fruits collected in South Florida range from 1 inch to 1¼ inches in diameter; but Indian journals report fruits 2 inches across (6) and it is said that those grown in the vicinity of Benares are especially noted for their size (49). Ripe fruits are astringent, extremely acid, and some are distinctly bitter. Mature trees are prolific[3] and, although the main crop in South Florida and India matures during the winter and early spring, a few fruits developed from late blooms are found in summer and fall. A number of emblic trees have borne fruit for many years in Cuba, Puerto Rico, Trinidad (53), Panama (45), and Hawaii (37), though little use has been made of the crop. These trees, like those in Florida, are all seedlings, and it is reasonable to assume that their fruits are much inferior to the best varieties of the East.

Fruit Composition

The content of the pulp is reported from India as follows: moisture, 81.2%; protein, 0.5%; fat, 0.1%; mineral matter, 0.7%; fiber, 3.4%; carbohydrates, 14.1%; calcium, 0.05%; phosphorus, 0.02%; iron, 1.2 mg./100 g.; nicotinic acid, 0.2 mg./100 g. (51). The Finlay Institute Laboratory, Havana, has supplied the following analysis: moisture, 77.1 g./100 g.; ether extract, .2 g./100 g.; carbohydrates, 21.8 g./100 g.; fiber, 1.9 g./100 g.; ash, .5 g./100 g.; calcium, 12.5 mg./100 g.; phosphorus, 26.0 mg./100 g.; iron, .48 mg./100 g.; carotene, .01 mg./100 g.;

[3]P. N. Bajpai, in a study of the fruiting habits of four fifteen-year-old trees, found an average yield of 415 fruits, which weighed approximately 24½ pounds. (6).

thiamine, .03 mg./100 g.; riboflavin, .05 mg./100 g.; niacin, .18 mg./100 g.; nitrogen, .07 mg./100 g.; tryptophan, 3.0 mg./100 g.; methionine, 2.0 mg./100 g.; lysine, 17.0 mg./100 g. (36). The fruit is high in pectin (51).

The ascorbic acid content of the emblic is considered highly stable, apparently protected by tannins and polyphenols which retard oxidation. Biochemical studies at the Central Drug Research Institute, Lucknow, show 13 separate tannins plus 3 or 4 colloidal complexes (18). Investigators at the Central Food Technological Research Institute, Mysore, believe the astringency of the emblic and the stability of its ascorbic acid may be attributed to the presence of polyphenols, or leucanthocyanins (41).

Ascorbic acid ratings vary: Dr. Juan Navia reported 625 mg./100 g. in Cuban fruits and 1,170 mg./100 g. in Florida-grown fruits analyzed by him in Havana (36). Professor Milton Kaplow found 467 mg./100 g. in fruit from Avon Park, Florida, and 1,130 mg./100 g. and 1,325 mg./100 g., respectively, in fruits from two adjacent trees in Homestead, Florida (29). Puerto Rican fruits were reported in 1945 as containing 900 mg./100 g. (3), while Dr. Margaret Mustard, in Florida, cited an average of 1,561.1 mg./100 g. and a high of 1,814 mg. (34). Even greater variation is found in the Barbados cherry, local specimens in Guatemala having tested as low as 17 mg./100 g. in contrast to Florida-grown fruits sent by air and analyzed there, which showed 1,420 mg./100 g. (2). Higher ratings, especially for unripe Barbados cherries, are not unusual (28).

Food Uses

In Thailand, where the tree is common in the forests, the fruits are favored by deer, especially the tiny barking deer. Wood-cutters eat the emblic to avoid thirst, as the fruit stimulates the flow of saliva (14). Rural folk in India claim that the highly acid, fresh, raw fruit, followed by water, produces a sweet and refreshing aftertaste (35). This reaction is consistently experienced by the writer but, in limited tests made by the Research Department of the Veterans Administration in Coral Gables, it was noted by only one out of seven tasters.

In Malaya, and to a greater extent in India, the emblic is an important and esteemed food, raw as well as preserved. Fruits from both wild and dooryard trees and from orchards, when ready to fall or freshly fallen, are gathered for home use and for market. Children eat the raw fruits with salt or sugar and sometimes with chili. Fresh emblics are baked in tarts (40), added as seasoning to other foods during cooking (10), and emblic juice is used to flavor vinegar (50). Both ripe and half-ripe fruits are made into preserves, sweetmeats, pickles and relishes. Emblic preserves are manufactured and marketed in such large quantities in India that the prevention of fermentation in storage has been the subject of special studies by Drs. Johar and Anand at the Central Food Technological Research Institute (25).

At various scientific institutions and other research centers in India, work is being carried on to improve present methods of processing, and to develop new products. N. L. Jain and G. Lal have devoted efforts to the preparation of a sirup retaining as much of the food value as possible. One-half of the original vitamin C content remained after one year in storage at room temperature (24). A concentrate containing 1,000 mg. of vitamin C/100 cc. has also been developed (51).

In the fruit-preserving industry, Indian technicians have evolved formulas for improved emblic preserves and jellies. When necessary, bitterness is overcome by soaking the fruits in a salt solution or by adding citrus fruit, unripe mango or tamarind (26). In preserving emblics whole, the fruit is first brined, washed and pricked, blanched in an alum solution, layered with

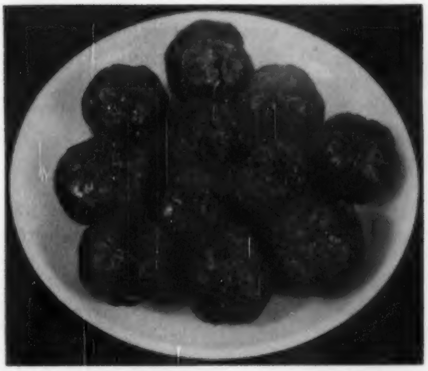

Fig. 4. Whole candied emblics received from Dr. L. B. Singh, Director, Government Horticultural Research Station, Saharanpur, India.

sugar until a sirup is formed, and boiled. It is then packed in enameled cans or crystallized as a confection (49). The whole candied fruits and the chips of dried flesh illustrated (Figs. 4 & 5) were received by the writer from Dr. L. B. Singh, Director of the Government Horticultural Research Station in Saharanpur. The dried flesh loses only 20% of its vitamin C content in a year when left in refrigerated storage, whereas 67% is lost in the same period at room temperature (51).

Special Dietary and Medicinal Uses

The emblic is regarded as sacred by many Hindus, and the Hindu religion prescribes that the ripe fruits be eaten for forty days after a fast in order to restore health and vitality (8). Mr. N. V. R. Iyengar, Scientific Officer of the Central Food Technological Research Institute at Mysore, when visiting at the University of Miami in July, 1955, told the writer that it is a common practice in Indian homes to cook the fruits whole with sugar and saffron and give one or two to a child every morning. According to Mr. Iyengar, a sauce made by cooking the chips in water, then mashing them in a mortar with caraway seeds, and further seasoning with salt and yogurt, is commonly eaten after fasting.

During the Second World War, emblic powder, tablets and candies were issued to Indian military personnel as vitamin C rations (35). The powder is superior to synthetic vitamin C in combatting deficiencies, as has been demonstrated in treating victims of pulmonary tuberculosis, and of the Hissar famine of 1939-40 (51). Drs. Rama Rao, Balakushnan and Rajagopalan, of the Institute of Science at Bangalore, describe a method of spray-drying emblic juice to produce a special powder for fortifying salt as a means of increasing vitamin C intake (39).

The emblic is of great importance in Asiatic medicine, not only as an antiscorbutic, but in the treatment of diverse ailments, especially those associated with the digestive organs. For such use, the juice is prepared in the form of a sherbet or is fermented. In the latter state, it is prescribed for jaundice, dyspepsia and coughs (10). The dried chips of flesh are dispensed by apothecaries and often are mixed with grape juice and honey for dosage. The fruit is considered diuretic and laxative (11). *Triphala*, a decoction of emblic with *Terminalia chebula* Retz. and *T. bellerica* Roxb. is given for chronic dysentery, biliousness (11), hemorrhoids, enlarged liver, and other disorders (51). Emblic leaves, too, are taken internally

Fig. 5. Dried emblic chips received from Dr. L. B. Singh, Director, Government Horticultural Research Station, Saharanpur, India.

for indigestion and diarrhea or dysentery, especially in combination with buttermilk, sour milk or fenugreek (16). The emblic has been tested for anticoagulant action by N. C. Pillai, G. J. S. Rao and M. Sirsi of the Indian Institute of Science, Bangalore. An aqueous extract of the mashed leaves prevented clotting of both plasma and whole blood, though there is some indication of agglutinins and lytic factors in the plant (38).

The plant is considered an effective antiseptic in cleaning wounds, and it is also one of the many plant palliatives for snakebite and scorpion stings (11). A decoction of the leaves is used as a mouthwash, and as a lotion for sore eyes (16). The juice that exudes when the fruit is scored while still on the tree is valued as an eyewash and an application for inflamed eyes. An infusion made by steeping dried fruit overnight in water also serves as an eyewash, as does an infusion of the seeds. An ointment made from the burnt seeds and oil is applied to skin afflictions (16). The seeds are used in treating asthma, bronchitis (51), diabetes and fevers (19). They contain proteolytic and lipolytic enzymes, phosphatides, and a small amount of essential oil. Approximately 16% consists of a brownish-yellow fixed oil of which the following analysis is reported by the Central Drug Research Institute, Lucknow: sp. gr.$^{31°}$, 0.9220; $n^{31°}$, 1.4758; acid val., 12.7; sap. val., 185; iod. val. (Wijs), 139.5; R. M. val., 1.03; acetyl val., 2.03; unsapon. matter, 3.81%; sterol content, 2.70%; and saturated fatty acids, 7.0%. The component fatty acids are: linolenic, 8.78%; linoleic, 44.0%; oleic, 28.40%; stearic, 2.15%; palmitic, 2.99%; and myristic acid, 0.95% (51).

The bark is strongly astringent and used in the treatment of diarrhea (15), and as a stomachic for elephants (10). The properties of leucodelphinidin in the bark have been determined by K. R. Laumas and T. R. Seshadri, Department of Chemistry, Delhi University (27). The flowers, considered refrigerant and aperient, and the roots, emetic (10), are also variously employed medicinally. The root bark, mixed with honey, is applied to inflammations of the mouth (19).

Other Economic Uses

Other uses in the East are numerous. In the tanning and dyeing industries, the fruit, leaves and bark of the emblic are highly valued and widely used in conjunction with other so-called myrobalans, especially fruits of various species of *Terminalia*. The twig bark is particularly esteemed for tanning leather and is often used with leaves of *Carissa spinarum* A.DC. and *Anogeissus latifolia* Wall. (50). Dyes from the leaves and fruit impart appealing light-brown or yellow-brown hues to silk and wool. When sulphate of iron is added as a mordant, the color becomes black (10). The dried fruit yields ink and hair-dye and, having detergent properties, is sometimes used as a shampoo (8). A fixed oil derived from the fruit allegedly acts as a hair-restorer. A most curious custom is the making of simulated pottery jars from a paste of the boiled fruit, the surface being decorated with impressed colored seeds (50).

The foliage and fruits furnish fodder for cattle (8), and branches are lopped for green manure. They are said to correct excessively alkaline soils (51). The hard but flexible red wood, though highly subject to warping and splitting, is used for minor construction, furniture and implements (10). Durable when submerged and believed to clarify water, it is utilized for crude aqueducts and inner braces for wells, and branches and chips of the wood are thrown into muddy streams for clarification (8) and to impart a pleasant flavor (19). The wood serves also as fuel and a source of charcoal (51).

Propagation and Culture

While the emblic has long been estab-

Fig. 2. This attractive, nine-foot emblic tree is one of a row of seedlings planted in 1955 at the Subtropical Experiment Station of the University of Florida, Homestead, Fla.

lished as an important and remunerative crop in India, the systematic culture of high-quality fruit is a relatively new development being actively promoted by the Indian Government.

The tree is propagated by seeds, cuttings, inarching, and budding; and the last is found the most practical method (22). Budding technique is described by Dr. L. B. Singh in an article in the February, 1952, issue of Science and Culture (42). Top-working of emblic trees bearing fruits of inferior quality is also recommended by Dr. Singh; trees being cut back to a height of four feet in March (at Saharanpur), and the new shoots budded in June (43).

At the Experimental Farm of the University of Miami in 1955, air-layers and cuttings were unsuccessful but root sprouts grew well and seed germination was 100% (29). Seeds were planted at the Subtropical Experiment Station, Homestead, in 1955, and the seedlings set out in the field in 1956. They survived unusually cold weather in the winter of 1957-58 and now are attractive, healthy young trees ranging from 8 to 9 feet in height (Fig. 2).

Indian horticulturists report that the emblic tree is subject to leaf rust caused by *Phakospora phyllanthi* Diet. and a ring rust caused by *Ravenelia emblicae* Syd. Thus far, it seems to be free of these

Fig. 3. Fruiting branches of the emblic and two half-fruits: left, a cross-section; right, an axial.

afflictions in Florida and it apparently is not attacked by the caterpillar that defoliates the related Otaheite gooseberry. It appears to grow equally well under both arid and humid conditions, and from sea-level to an altitude of 4,500 feet (51).

Conclusion

The emblic, while inferior to the Barbados cherry in eye-appeal and for eating out-of-hand, has the commercial advantage of being a firm, long-lasting fruit. It lends itself to mass harvesting, bulk packing, and long-distance transportation to processing centers. The tree is a graceful, wind-resistant (47) ornamental, and flourishes without horticultural attention in regions too dry and soil too poor for most other fruit crops. Large-fruited varieties with high ascorbic acid content might well be introduced into tropical America and other areas where there is especial need for increasing the amount of vitamin C in the diet. With this in mind, Dr. Robert Harris suggests that the fruit might best be utilized in the preparation of a nutritional drink (21).

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Processing of Pistachio Nuts

New mechanical procedures for processing pistachio nuts make economical preparation for marketing possible in the United States. These new developments include mechanical dehulling, methods for separating empty nuts from those with well developed kernels, and methods for separating split nuts from those with closed shells.

FELIX BLOCH and JOHN E. BREKKE[1]

Introduction

The pistachio nut tree, *Pistacia vera* L., has been extensively cultivated since ancient times in the Middle Eastern and Mediterranean countries; in India and Afghanistan, crops are obtained from wild trees. The climatic conditions favorable to pistachio culture (5, 6) are similar to those for almonds and olives, and prevail in extensive regions of the western United States. Several orchards are well established in the interior valleys of California, where the tree was introduced about 65 years ago. In spite of the demand for pistachio nuts in this country as shown by the tonnage and value of the imports (Table I), pistachio culture has not expanded. Lack of labor-saving, technological production and processing methods are thought to be responsible for holding back the wider expansion of pistachio culture in this country (5). A comprehensive review on pistachio culture was published by Whitehouse (5); in the present paper only processing problems will be discussed.

Pistachio nuts are borne in clusters; the seed color ranges from light yellow to deep green throughout, and the leathery husk shows different shades of yellow, red, and purple. It is peculiar to the pistachio nut, that, when ripe, a large proportion of the nuts split along the shell suture. This splitting property is highly desirable as pistachio nuts are usually marketed in-shell, to be opened by the consumer.

The nuts are harvested by knocking them off the tree with poles, by shaking onto sheets, or by use of mechanical shakers. When harvested, the nuts usually contain 40 to 45% moisture and must be dried in the hull, or dehulled and dried immediately; otherwise, heating and spoilage occur. Usually, the drying is accomplished by spreading the nuts on screens and drying them in the sun and open air. In Iran (1), the nuts are spread on stone, concrete, or mud-packed earth.

The hulls of the freshly harvested pistachio nuts slip off fairly easily. In Iran the hulls are manually removed at this stage (5). If the nuts have been dried in-hull for storage, they are soaked in water for a short time to ease removal of the hulls. In Turkey, removal of hulls is accomplished by rubbing the nuts with stone rollers, followed by separation of the nuts from the loose hulls by means of a kind of fanning mill (5). Occasionally, the hulls are removed by a man wearing rubber boots treading the nuts in a tank of water, followed by manually transferring and washing from one pail to another and back, until the nuts are free from hulls. Attempts in the United States to use almond and walnut hullers were not entirely successful because of excessive breakage of shells or failure to dehull a large percentage of nuts.

Some Properties of Pistachio Nuts

Pistachio nuts were procured from the USDA Plant Introduction Station, Chico, California. Several of the varieties under study at Chico were used as follows: The 'Damghan' and 'Kerman' varieties are selections of seedlings grown at Chico from seed which originated in Iran (5,

[1]Western Regional Research Laboratory, Albany 10, California. A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

TABLE I

IMPORTS OF PISTACHIO NUTS TO USA

	Shelled		Unshelled		Total, Unshelled Basis[1]	
Fiscal Year	*Lbs.*	*Value, $*	*Lbs.*	*Value, $*	*Lbs.*	*Value, $*
1952-53	290,000	208,000	5,887,000	3,121,000	6,467,000	3,329,000
1953-54	236,000	212,000	3,892,000	2,421,000	4,364,000	2,633,000
1954-55	273,000	230,000	7,365,000	2,985,000	7,911,000	3,215,000
1955-56	262,000	263,000	5,578,000	2,828,000	6,102,000	3,091,000
1956-57	358,000	275,000	8,633,000	4,791,000	9,349,000	5,066,000
1957-58	420,000	250,000	8,532,000	3,810,000	9,372,000	4,060,000

[1] 1 pound shelled equivalent to 2 pounds unshelled.

Compiled from Yearly Reports, Foreign Agricultural Trade of the United States, USDA Foreign Agricultural Service, Washington, D. C.

6); 'Red Aleppo' is of Turkish origin; and 'Bronte' and 'Trabonella' were introduced from Sicily.

There is a wide range in the size of pistachio nuts as expressed by the number of nuts per ounce. It is reported (1) that the pistachios from Iran range from 18 to 40 nuts per ounce. Nuts as large as 14 per ounce (198 g./100 nuts) were separated from a Chico sample (see Table VII) by means of a mechanical classification method to be described below. Data on the characteristics of the nuts are not an evaluation of the varieties used, but are measurements made as part of the evaluation of processing and classification methods developed at this laboratory. Varietal comparisons and evaluations are found in previous papers (1, 5, 6).

The chemical composition of pistachio nut kernels, shells, and hulls of split and unsplit nuts of one variety is shown in Table II. The chemical composition of pistachio nut meats of several varieties is given in Table III. Apparently, the varieties differ in oil content (ether extractable). The protein content is inversely correlated with the oil content; the coefficient of correlation is —0.96. Because of the high price of pistachio nuts, the oil is not produced commercially. The fat characteristics and fatty acid composition, compiled from the literature, are presented in Table IV. About 90% of the fatty acids present in pistachio oil consist of the unsaturated oleic and linoleic acids.

Experimental Processing

Dehulling of Pistachio Nuts. Abrasive peeling machines were found suitable for dehulling pistachio nuts both in the fresh state immediately after harvest, or after

TABLE II

CHEMICAL COMPOSITION OF PISTACHIO NUT KERNELS, SHELLS, AND HULLS
RED ALEPPO VARIETY, 1957 CROP.

	Kernels		Shells		Hulls	
	Split Nuts	*Unsplit Nuts*	*Split Nuts*	*Unsplit Nuts*	*Split Nuts*	*Unsplit Nuts*
			% on Dry Basis			
Protein (N × 6.25)	19.41	19.58	0.42	1.06	7.66	9.35
Oil, ether extractable	58.3	54.7	0.56	0.58	7.82	8.27
Crude fiber	1.74	2.19	54.0	53.4	14.1	17.4
Ash	2.95	3.55	0.42	1.06	15.56	13.30
Calcium	0.13	0.13	0.06	0.06	0.07	0.25
Potassium	1.04	1.22	0.22	0.49	6.71	5.88
Phosphorus	0.54	0.64	0.02	0.04	0.12	0.24

Harvested at the USDA Plant Introduction Station at Chico, California.

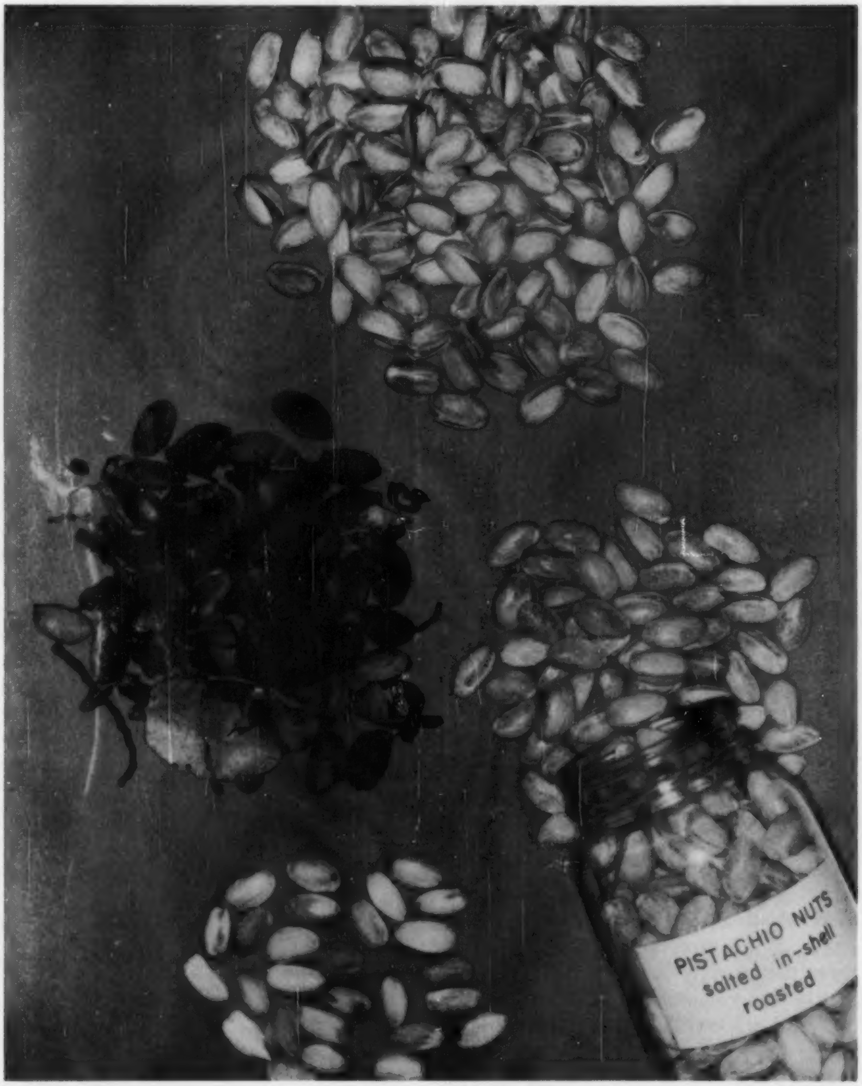

Fig. 1. Top center: Pistachio nuts before dehulling. Right: Split-shell pistachio nuts after abrasive dehulling and separation. Left, top: Unsplit pistachio nuts after separation Left, bottom: Pistachio nuts after processing by salting in-shell and roasting.

TABLE III

CHEMICAL COMPOSITION OF PISTACHIO NUT MEAT FROM SPLIT NUTS.

	Red Aleppo			*Kerman*		*Trabonella*		*Bronte*
	1956	*1957*	*1958*	*1956*	*1958*	*1956*	*1958*	*1956*
	% on Dry Basis							
Protein (N × 6.25)	23.00	19.41	21.56	26.75	28.88	24.25	24.13	24.81
Oil, Ether extractable	54.4	58.3	58.0	50.6	48.3	54.6	55.7	53.2
Crude fiber	1.81	1.74	1.65	2.11	1.93	1.74	1.97	2.11
Ash	3.34	2.95	3.18	2.95	3.50	2.90	2.85	3.03
Phosphorus	0.57	0.54	0.56	0.54	0.64	0.50	0.49	0.55
Calcium	0.14	0.13	0.16	0.11	0.10	0.18	0.11	0.18
Magnesium	0.17			0.15		0.17		0.18
Potassium	1.07	1.04	1.15	0.93	1.18	0.86	1.06	0.92
Total sugar (as sucrose)[1]	7.2		7.5	8.4	7.9	6.1	6.2	6.4

Harvested at the USDA Plant Introduction Station at Chico, California.
[1]Paper chromatography showed sucrose and raffinose present in about equal proportion.

drying in the hull. These machines consist of an upright cylinder coated on the inside surface with an abrasive; the bottom of the cylinder is a rapidly rotating disc, also coated with an abrasive. The material to be peeled is thrown by centrifugal force of the rotating disc against the abrasive wall surface, while a stream of water, introduced on top of the cylinder through a perforated ring, soaks the material and flushes the disintegrated hulls, etc., to a catch basket. The product recovered from the abrasive treatment and subsequent separation and drying needed no additional labor for cleaning and sorting (Fig. 1).

The machine available for the experiments was the Blakeslee Model 20 No-Gear Potato & Vegetable Peeler[2] equipped with ¼ H.P. motor (Fig. 2a). Commercially available abrasive peeling machines of this type range in size up to 3½ times the capacity of the "Model 20" used for the experiments (Fig. 2b).

There are continuous peelers available equipped with pairs of carborundum-coated rolls. These machines may hold some promise when larger capacities make continuous machines desirable; their suitability for dehulling pistachio nuts has not yet been established, however.

[2]Mention of specific products does not imply endorsement by the U. S. Department of Agriculture over others of a similar nature not mentioned.

For freshly harvested pistachio nuts, the capacity of the machine was 20 pounds. The split pistachios were freed from their hulls in 1½ minutes; the dehulling operation was continued until the hulls of the unsplit pistachio nuts, which adhere more tightly to the shells, were removed, and complete dehulling took up to 6 minutes. The nuts are not damaged by the abrasive treatment, but polishing and cleaning action takes place so that the shells are attractively light in color, as compared to those dehulled by any other method.

The moisture content at the different stages of the processing was as follows:

Pistachio nuts, as harvested	41.8%
After 1½ minutes of abrasive dehulling	43.8%
After 6 minutes of abrasive dehulling	45.0%
After drying on tray drier	4.0%

Freshly harvested pistachio nuts of three varieties gave the following yields of dehulled and dried nuts:

Kerman	31.4%
Trabonella	38.7%
Red Aleppo	40.7%

The yields, of course, vary with the moisture content of the freshly harvested nuts, and depend also on the weight of impuri-

ties, like twigs, leaves, etc., which accompany the nuts and are eliminated by the abrasive dehulling procedure. In Iran (Whitehouse, quoted by Bembower, 1956) the yield of dry dehulled nuts usually runs about 33% of the weight of the fresh nuts.

For pistachio nuts dried in-hull, the capacity of the small abrasive peeler (Fig. 2a) was 12 pounds. The capacity of the larger machine (Fig. 2b) was 45 pounds. It took 6 to 8 minutes for complete dehulling. The yields, calculated on equal moisture basis, were as follows:

Red Aleppo, 1957	77.0%
Red Aleppo, 1958	76.0%
Kerman, 1958	75.0%
Trabonella, 1958	70.2%

The abrasive dehulling, whether done on the freshly harvested pistachio nuts or on the nuts dried in-hull, was followed by a process of separation of split from unsplit nuts.

Separation of Split and Unsplit Pistachio Nuts. At the time of harvest, the shells of a large proportion of pistachio nuts are split at the suture at the apical end (Fig. 1). The demand is for the split pistachios and much time and labor are spent in the middle eastern countries to separate manually the split from the unsplit nuts.

The kernels of the unsplit pistachio nuts are usually not fully developed; a high percentage are shriveled or empty. The ratio of meat to shells and the 100-kernel weight is, therefore, lower than on the split pistachios:

1957 Crop, Red Aleppo Variety Pistachio Nuts

	Split	*Unsplit*	*Composite*
Wt. 100 nuts, grams	114	81	108
% Meat	53.8	36.2	51.1

When immersed in water, most of the dehulled, dried pistachio nuts in-shell floated, regardless of whether they were split or unsplit. If, however, immediately after the abrasive dehulling operation, the wet nuts were discharged into water, all unsplit nuts floated and 60 to 80% of the split nuts sank. Determination of the apparent specific gravity of sinkers and floaters indicated a sufficient difference in the specific gravities of split and unsplit pistachio nuts to make a separation procedure possible:

Pistachio Nuts in-Shell, Dried to 4% Moisture

	Sinkers (all split)	*Floaters Split*	*Floaters Unsplit*
Specific Gravity	1.09	1.09	0.625
Weight of 100 nuts, g.	125	120	90
% Meat	55.7	55.2	37.5

The specific gravity was determined by means of a 100-ml. glass cylinder as pycnometer and toluene as displacement liquid. A small copper screen, tared with the cylinder, kept floating nuts submerged. The specific gravities of pistachio nut meat and of the shells were as follows:

	Specific Gravity
Nut meat (3.1% moisture)	0.97
Shells (6.8% moisture)	1.22

Calculation of the specific gravity of split nuts from the proportions and specific gravities of the components (meat and shells) gave a value of 1.09, the same as

TABLE IV

PISTACHIO OIL

Fat Characteristics	
Acid Value	0.5 - 4
Saponification Value	191 -195
Iodine Value	84 - 94
Reichert-Meissl Value	0.5
Unsaponifiable (%)	0.4 - 1.0
Refractive Index, n_D, 40° C.	1.467- 1.470
Specific Gravity, 15/15° C.	0.918- 0.920
Titer (° C.)	13 - 16
Melting Point	about 5
Fatty Acid Composition	*Weight % of Total*
Saturated	
Myristic	0.6
Palmitic	8.2
Stearic	1.6
Unsaturated	
Oleic	69.6
Linoleic	19.8

E. W. Eckey, Vegetable Fats and Oils. Reinhold Publishing Corporation, New York (1954).

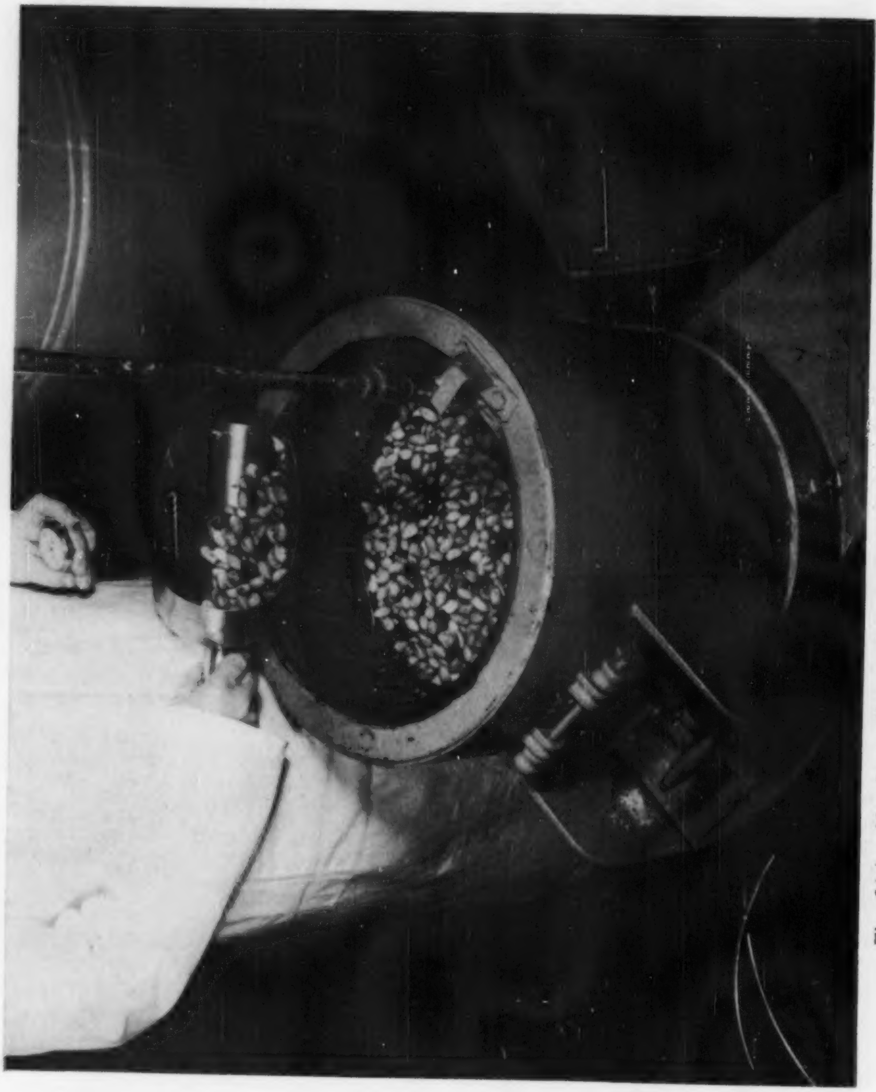

Fig. 2(a): Abrasive peeling machine, experimental model, during dehulling procedure.

Fig. 2(b): Abrasive peeling machine. Large model, in use for pistachio dehulling.

determined; however, for the unsplit nuts, the specific gravity calculated from the components figured 1.13, compared to the determined specific gravity of 0.625. It is only the enclosed air that makes pistachio nuts float on water. This was indeed shown when, by application of a vacuum under water, the air was drawn out from the unsplit nuts through the shells; after the vacuum was broken, both the unsplit and split nuts sank. When pistachio nuts dried in-hull were allowed to absorb mois-

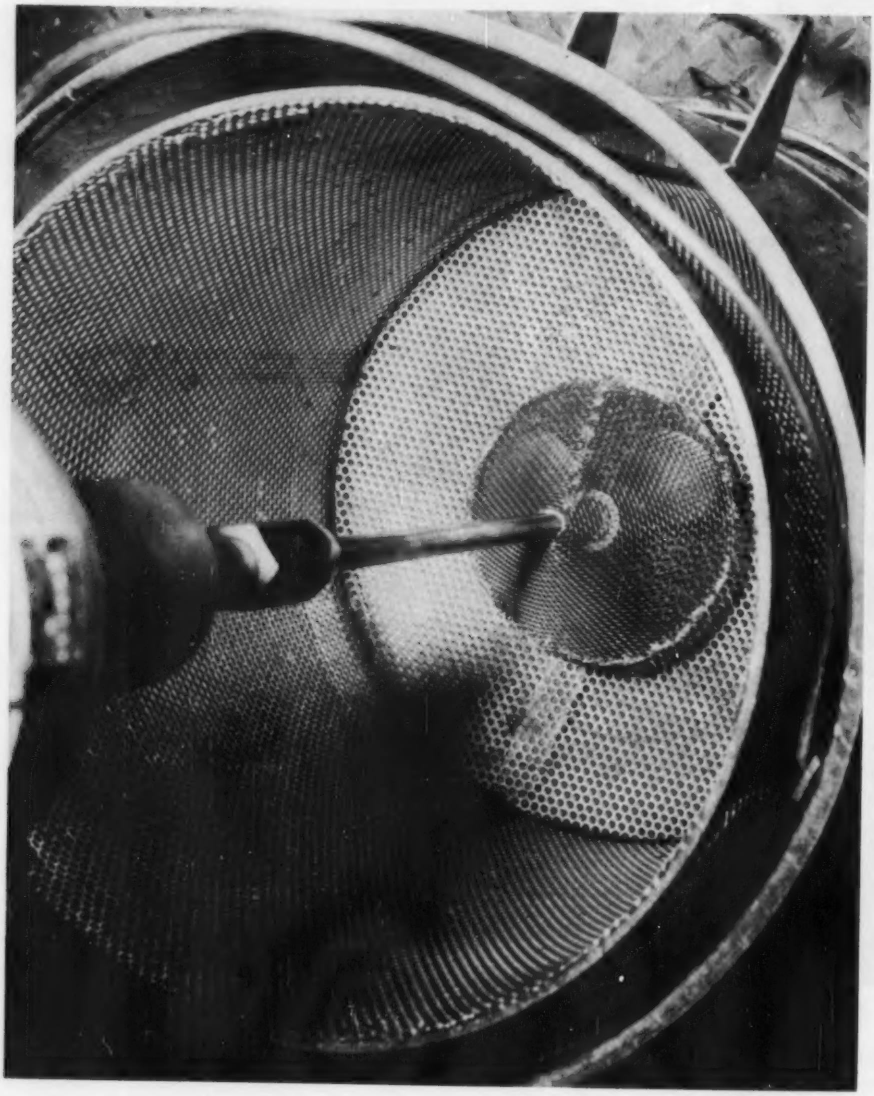

Fig. 3. Equipment for separation of split and unsplit pistachio nuts.

ture during the abrasive dehulling, the apparent specific gravity was again found to be 1.09 for the split nuts and 0.63 for unsplit; thus a separation based on the difference in apparent specific gravities is not dependent on the moisure content of the nuts at levels reached during abrasive dehulling of nuts dried in-hull after the harvest. However, when freshly harvested pistachio nuts, which as a rule show a moisture content of 35 to 45%, were subjected to abrasive dehulling, and subsequently were discharged into water, a different kind of separation took place: a portion of the unsplit nuts sank with the split nuts. This behavior is discussed below.

The expulsion of air from split pistachio nuts immersed in water was accomplished by application of centrifugal force. Pistachio nuts were immersed in water and centrifuged on a laboratory centrifuge in 200-ml. cups for 2 minutes at 1000 RPM; the split nuts sank while the unsplit nuts floated. Similar results with 94 to 96% separation efficiencies were realized with a 17-inch basket centrifuge equipped with 1500 RPM drive.

A high-speed stirrer removed the air entrapped in the split pistachio nuts as effectively as a centrifuge, provided the nuts were protected by a screen from being broken by the impact of the propeller. The equipment is shown in Fig. 3. A 17-inch diameter screen basket was inserted in a 19-inch diameter tank, which was filled with 100 pounds of water to a height of about 10 inches. A Lightnin' Mixer, 1750 RPM, had its 6-inch marine-type propeller equipped with a cone-shaped ⅛-inch mesh screen attached to, and rotating with, the agitator shaft.

The separation of split from unsplit nuts is preferably done following the dehulling process; the separation works in different ways, depending on whether the nuts are dehulled immediately after harvest or after drying in-hull.

Freshly harvested pistachio nuts, dehulled in the abrasive machine (Fig. 2a) were discharged through the discharge gate of the peeling machine into the tank with stirrer described above (Fig. 3). All split nuts and the full unsplit nuts sank. The floaters were unsplits only, with less than 15% meat content. The floaters were scooped off, and the sinkers were removed by lifting the basket. The two fractions were dried on trays at 95 to 100° F. Table V lists the properties of the two fractions.

In order to separate the sinkers into split and unsplit nuts, the dried sinkers were subjected to a re-separation with the same equipment by agitation in water for about 6 minutes. After the agitation was discontinued, the nuts were allowed to separate into floaters and sinkers. The floaters were practically 100% unsplits, the sinkers, practically 100% splits. The efficiency of separation (calculated on weight basis as the percentage of split nuts separated as sinkers and the percentage of unsplit nuts separated as floaters) was as follows:

	On the Splits	*On the Unsplits*
Kerman, 1958	96.1%	98.9%
Red Aleppo, 1958	94.5%	100 %
Trabonella, 1958	98.8%	100 %

The proportions of the three fractions were as follows:

	Splits	*Full Unsplits*	*Empty Unsplits*
Kerman, 1958	55.3	12.8	31.9 % of Total
Red Aleppo, 1958	77.3	12.4	10.3 % of Total
Trabonella, 1958	82.3	7.5	10.2 % of Total

Pistachio nuts dried in-hull were dehulled on the abrasive machine as described previously and discharged into water. The nuts were stirred for 1 to 4 minutes and allowed to separate into floaters and sinkers. The floaters and the sinkers were dried at 95 to 100° F. The efficiency of separation, determined by manual sorting of the two dried fractions into splits and unsplits, was as follows:

Variety	Separation Efficiency on *Splits*	*Unsplits*
Red Aleppo, 1958	96.5%	100 %
Trabonella, 1958	97.7%	97.9%
Kerman, 1958, Lot 1	80.5%	100 %
Kerman, 1958, Lot 2	92.2%	100 %

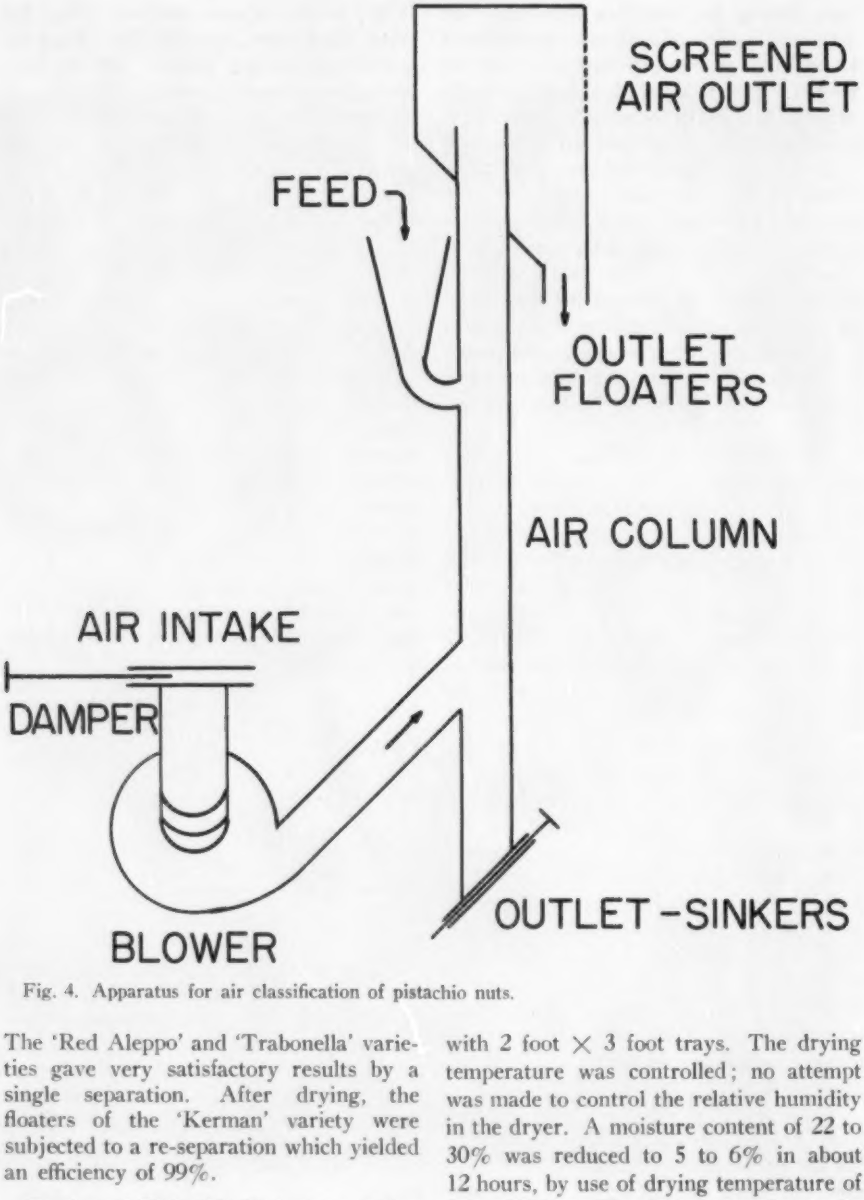

Fig. 4. Apparatus for air classification of pistachio nuts.

The 'Red Aleppo' and 'Trabonella' varieties gave very satisfactory results by a single separation. After drying, the floaters of the 'Kerman' variety were subjected to a re-separation which yielded an efficiency of 99%.

Drying of Pistachio Nuts. The drying equipment used for the present experiments was a forced air dryer equipped with 2 foot × 3 foot trays. The drying temperature was controlled; no attempt was made to control the relative humidity in the dryer. A moisture content of 22 to 30% was reduced to 5 to 6% in about 12 hours, by use of drying temperature of 95 to 100° F. The drying time for freshly harvested pistachio nuts with up to 45% moisture was about 18 hours.

Grading of Pistachio Nuts by Air Classification. A method was developed to classify unsplit pistachios into grades of different kernel development, in order to eliminate the worthless empty or almost empty nuts. Air classification methods have been found effective; these methods have also been found useful for grading split pistachios into grades of different size. The process of air classification is based on the capacity of an air stream to lift particles against gravity. The effect depends on air velocity and the shape, size, and specific gravity of the particles. The precise effect of the factors mentioned is not predictable; however, the lifting power of an air stream is a function of the square of the air velocity, and small changes in air velocity are effective in bringing about varied results in the classification of pistachio nuts. The apparatus used for the experimental air classification was a vertical column (Fig. 4); the air volume and velocity were regulated by the transmission ratio to the blower and by the position of a damper on the air intake.

Table VI gives evidence of the effectiveness of single pass air classification for the fractionation of unsplit pistachio nuts into floater fractions with a negligible meat content, and sinker fractions with developed kernels which possess commercial value. Table VII shows the results of single pass air classifications of split pistachio nuts at different air velocities.

In order to separate more than two fractions, the air classification was performed by multiple passes through the air column. Two variations of multiple passes were established: a) Classification at increasing air velocities, starting the first classification at an air velocity capable of producing a floater fraction and feeding the sinker fraction to the next pass at an increased air velocity, collecting the floater fractions of every pass, and collecting the sinker fraction of the final pass. b) Multiple classifications at decreasing air velocities, collecting the sinkers of the first pass and feeding the floaters to the next pass at a decreased air velocity, etc. Table VIII shows the properties of the fractions obtained by multiple

TABLE V

PROPERTIES OF THE FRACTIONS OF PISTACHIO NUTS, SEPARATED AFTER DEHULLING FRESHLY HARVESTED PISTACHIOS

	Sinkers		*Floaters*
Variety	*Split*	*Unsplit*	*All Unsplit*
Kerman (1958)			
Spec. Grav.	1.035	0.81	0.53
Weight of 100 nuts, g.	136.5	129.7	88.9
Weight of meat, 100 nuts	67.8	58.8	12.8
Weight of shells, 100 nuts	68.7	69.9	76.1
% Empty nuts	0	0	74
Trabonella (1958)			
Spec. Grav.	1.05	0.89	0.655
Weight of 100 nuts, g.	80.0	76.7	52.4
Weight of meat, 100 nuts	40.8	30.6	3.4
Weight of shells, 100 nuts	39.2	46.1	49.0
% Empty nuts	0	0	83
Red Aleppo (1958)			
Spec. Grav.	1.02	0.89	0.565
Weight of 100 nuts, g.	119.8	106.0	75.2
Weight of meat, 100 nuts	65.5	50.2	14.8
Weight of shells, 100 nuts	54.3	55.8	60.4
% Empty nuts	0	0	77

(All nuts were dried to about 5% moisture)

pass classifications of unsplit nuts. When continuous operation is desired, multiple passes can be arranged by providing a number of air columns maintaining the desired air velocity in each column, and transferring the proper fraction from one column to the next.

The method of air classification is also suitable for the separation of pistachio nut meat from the shells after a shelling process. At an air velocity of 4000 f.p.m., all the shells collected in the floater portion. In this case, the shells having a specific gravity of 1.22, were separated as floaters, and the nut meats, having a specific gravity of 0.97, were collected in the sinker fraction.

Salting and Roasting of Pistachio Nuts in-Shell. Most pistachio nuts reach the consumer salted and roasted in-shell. Though this processing is done commercially, no details on equipment and procedures are described in the literature.

The experimental roasting was performed on a tumbling-screen drier in forced air at controlled temperatures. The tumbler drum (18 inch × 18 inch diameter) rotated at 5.7 RPM. The salting was accomplished by dipping the pistachio nuts in-shell into a salt solution of 15 to 20 pounds of salt in 100 pounds of water. When the pistachio nuts were processed immediately after abrasive dehulling, they were subjected to a drying process in order to reduce the moisture to 5 to 10% before dipping in brine, in order to facilitate the uptake of brine. The nuts took up more salt, and in less time, if they were stirred in a brine solution by means of the screened agitator (Fig. 3), than if they were merely soaked; the stirring served to expel air that was trapped in the shells of the split nuts:

	Salt Uptake %
10 minutes soaking in 15% salt solution	0.81
20 minutes soaking in 15% salt solution	0.96
1 minute agitating in 15% salt solution	1.87

There is a wide leeway, as far as the drying temperatures are concerned. However, temperatures above 250° F. have been found to effect a darkening of the kernels; for this reason it is advisable not to expose the pistachio nuts to roasting temperatures when the moisture is extremely high, as may be the case when processing freshly harvested pistachio nuts. Consistent, good results were obtained with the following roasting schedule: the pistachio nuts, salted by treatment with a salt solution, were dried in the rotary-screen drier at 160° F. for about 30 minutes, until the moisture taken up by the salting was removed. Then, the temperature was raised in 30 minutes to 248° F., and held at 248° F. for 10 minutes.

As far as is known, there are no in-shell oil-roasted pistachio nuts on the market. Split-shell pistachio nuts were salted by soaking in 15% (wt./vol.) salt solution for 30 minutes. After draining, the nuts were dried at 150° F. for 1½

TABLE VI

SINGLE-PASS AIR CLASSIFICATION OF UNSPLIT PISTACHIO NUTS

Variety	*Air Vel. fpm.*	*Fraction*	*Weight of Fraction %*	*Weight of 100 Nuts gm.*	*Meat %*
Red Aleppo	7,060	Floaters	30.3	70.6	10.2
		Sinkers	69.7	110.1	46.6
Trabonella	7,060	Floaters	22.3	61.6	11.1
		Sinkers	77.7	92.0	42.9
Kerman	7,060	Floaters	15.6	84.6	3.0
		Sinkers	84.4	152.3	40.5
	8,700	Floaters	25.1	94.0	9.0
		Sinkers	74.9	160.0	43.0

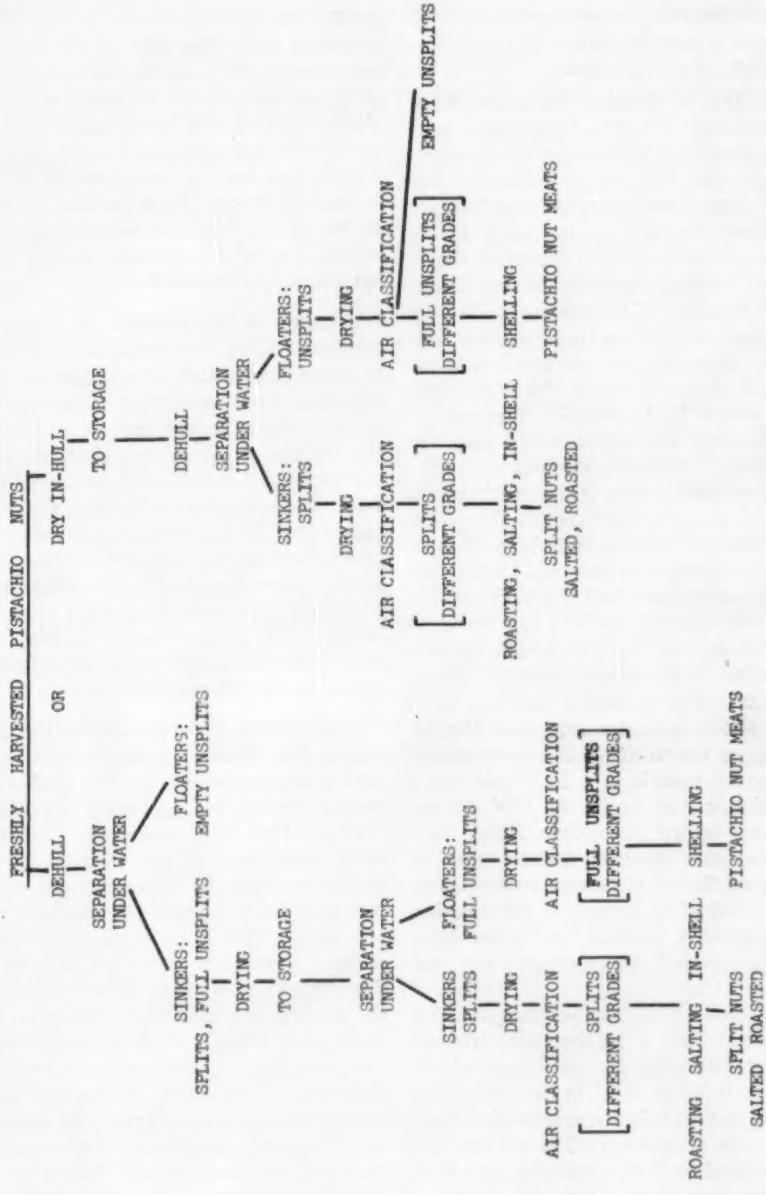

Fig. 5. Scheme of sequence of processing operations.

hours, roasted in peanut oil for 7 to 8 minutes, and finally centrifuged 5 minutes at 2000 RPM to remove excess oil. The appearance and the flavor of these nuts were judged as very good.

Roasting of Shelled Pistachio Nuts. The roasting of shelled pistachio nuts may increase in interest as it represents an outlet for the unsplit pistachio nuts with developed kernels which can be separated and classified by the methods developed in this study and described above. Suitable shelling machines causing no excessive breakage of kernels are needed for this purpose. There are shelled, oil-roasted pistachio nuts marketed in vacuum packed cans, among them pistachio nuts grown in California. Commercial nut roasting equipment lends itself to processing of shelled pistachios.

Experiments were performed on a limited scale to secure some information as to suitable oils, the salting procedure and the cooking temperatures. Cottonseed and peanut oil were found equally acceptable; coconut oil seemed to transmit flavor of its own, which, though not objectionable, masked the pistachio flavor somewhat. The pistachio kernels were either salted with dry salt after the oil cooking or the salting was performed by soaking the kernels in a 15% (wt./vol.) salt solution and drying at 150° F. for 1½ hours before oil cooking. Either salting procedure gave oil-roasted nuts of very good flavor. In direct comparisons, the nuts salted by soaking in salt solution were preferred, perhaps due to the saltiness distributed all through the nut kernel.

The cooking oil temperatures which were set at 284° F. at the start, dropped to about 240° after the nuts were added, and rose to about 290° at the end of the cooking as the moisture evaporation from the kernels progressed. The oil roasting was finished in 7 to 8 minutes; the final moisture was about 1.5%. In order to remove excess cooking oil, the nuts were spun in a basket centrifuge for 5 minutes at 1500 RPM. Dry-roasted, shelled pistachio nuts were produced from kernels of unsplit nuts. The full unsplit pistachio nuts were freed from the unfilled nuts by air classification. The full nuts were then shelled and the nut meats soaked in 20% (wt./vol.) salt solution for 15 minutes. Drying and roasting was accomplished on a tumbler dryer. After holding at 150° F. for 30 minutes, the temperature was raised during 20 minutes to 240° and held there for 10 minutes.

Scheme of Processing. In order to prevent spoiling, the pistachio nuts must be dried immediately after harvest. The dehulling (and separation of split pistachio nuts from unsplit nuts) may precede the drying, or the dried pistachio nuts may be stored in-hull until processed further. The advantage of drying and storing in-hull is the lessened possibility of insect damage (5) and relief of the work load at harvest time. On the other hand, one drying operation is omitted when dehulling takes place immediately after harvest. Figure 5 depicts the scheme of processing for the two alternatives.

Equilibrium Moisture Content of Pistachio Nut Meat. The equilibrium moisture content is of interest for studies on drying, storage, and packaging conditions. The sorption and desorption isotherms were determined at 34° F. and 85° F. Meat from split-shell pistachio nuts which had been dried to about 6% moisture was ground in a Wiley mill through a 20 mesh screen. Aluminum dishes (5 cm. dia. × 2 cm. high) containing 3 to 4 grams of the ground nut meat were placed in the desiccators above sulfuric acid of known concentration. After evacuation, the desiccators were placed in rooms at controlled temperature. Triplicate samples were weighed periodically until constant weight (less than 1 mg. change in 24 hours) was reached. The total solids content of the nut meat, ground through 20

TABLE VII

SINGLE-PASS AIR CLASSIFICATION OF SPLIT PISTACHIO NUTS

Variety	*Air Vel. fpm.*	*Fraction*	*Weight of Fraction %*	*Weight of 100 Nuts gm.*	*Meat %*
Red Aleppo	8,550	Composite		120.3	54.5
		Floaters	5.3	86.7	52.9
		Sinkers	94.7	121.0	54.6
Trabonella	8,550	Composite		91.0	51.2
		Floaters	10.3	76.8	51.8
		Sinkers	89.7	93.0	51.1
	10,700	Composite		139.3	49.8
Kerman		Floaters	75.9	128.5	49.2
		Sinkers	24.1	198.0	49.9
	9,100	Composite		134.5	49.4
		Floaters	22.8	121.7	48.9
		Sinkers	77.2	138.7	49.4

mesh, was determined by vacuum drying (1 to 2 mm. Hg) at 70° C. for 6 hours. This method of determining moisture was established experimentally and used throughout the present investigation.

The specific gravity of the sulfuric acid solutions was determined on a Westphal balance and again checked after the equilibrium was achieved. The sulfuric acid concentrations were calculated from the specific gravity using the table in Landolt-Börnstein, Physikalisch-Chemische Tabellen, Ed. 5, Vol. 1, p. 397. The relative humidities corresponding to the sulfuric acid concentrations at the temperature of equilibrium were calculated according to R. E. Wilson (7). The results are plotted in Fig. 6.

The S-shaped moisture equilibrium curves (Fig. 6) for pistachio nut meat show an inflection point in the neighborhood of 3.5% moisture. In this region the moisture is believed to be adsorbed in a multimolecular layer; below this region,

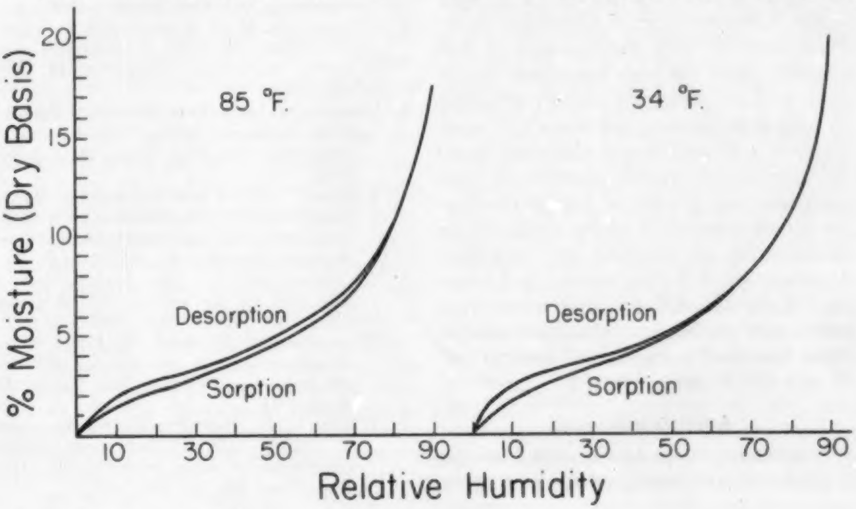

Fig. 6. Moisture equilibrium curves of pistachio nut meat.

TABLE VIII

MULTIPLE-PASS AIR CLASSIFICATION BY INCREASING AIR VELOCITIES
UNSPLIT PISTACHIO NUTS, KERMAN VARIETY (1958)

Air Vel. fpm.	*Fraction*	*Weight %*	*100 Nuts Weight grams*	*Meat Content %*
6250	Floaters	15.72	60.0	0
7830	Floaters	9.72	78.6	7.3
8740	Floaters	6.75	97.7	23.1
9080	Floaters	8.42	108.0	32.4
9120	Floaters	6.97	114.7	36.4
10200	Floaters	7.03	125.6	41.6
10300	Floaters	7.93	127.9	44.4
10700	Floaters	6.26	138.2	46.2
10700	Sinkers	31.18	141.5	48.0

the adsorption is thought to be monomolecular; and above it, the moisture is thought to be condensed in capillaries (2, 3). The region around the inflection point on the equilibrium curve probably indicates conditions for optimal stability. For shelled walnuts, optimal stability as to odor, color, and flavor, have indeed been correlated with the moisture content at the inflection point (4).

Summary

Lack of technological processing methods for pistachio nuts has been a limiting factor in development of pistachio culture commensurate with the demand in this country. New methods have been developed, and are presented, for: 1) dehulling by means of abrasive machines; 2) separation of split and unsplit pistachios based on difference in specific gravity; 3) classification into grades of kernel development and removal of empty shells by air classification at specified air velocities; 4) processes of drying, salting, and roasting. Compositional data and other properties are presented. Moisture equilibrium curves of pistachio nut meat at 34° F. and 85° F. are presented.

Acknowledgment

The supply of pistachio nuts from the USDA Plant Introduction Station at Chico, California, and the valuable cooperation of Lloyd E. Joley, Horticulturist in Charge of the Station, are most gratefully acknowledged. The authors also wish to acknowledge technical assistance by Lynus Richards. The analytical work reported in Tables II and III was performed by the analytical group under the supervision of K. T. Williams at the Western Regional Research Laboratory.

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Market Diseases of Fresh Fruits and Vegetables[1]

Bruising, crushing, and other mechanical injuries cause very serious losses during the handling, transportation, storage, and marketing of fresh fruits and vegetables. Spoilage caused by molds and bacteria exacts a heavy toll. Freezing, chilling injury, and various physiological disorders add to the consumer cost of living. Careful handling, proper refrigeration, good marketing practices, and the use of safe, approved chemical treatments can reduce marketing losses.

B. A. FRIEDMAN[2]

Introduction

Market diseases include the defects, blemishes and decays found on fresh fruits and vegetables at the commercial and consumer level. While some of these diseases occur in the field and orchard, many develop after harvest, in transit or storage, during processing and marketing, or in the kitchen. Market diseases include the common parasitic diseases as well as the defects and blemishes caused by environment, physiological, mechanical and other factors. Losses caused by the parasitic organisms are accounted for principally by bacterial soft rot, blue mold rot, gray mold rot, fusarium rot, watery soft rot, rhizopus rot, alternaria rot, cladosporium rot and anthracnose rot. Other decay-producing organisms that attack only certain groups of fruits and vegetables may nevertheless cause serious losses. Among these may be mentioned brown rot of stone fruits, stem-end rot of citrus, mycosphaerella rot of watermelons and cucumbers, black rot of pineapples and bananas, late blight of potatoes and tomatoes. Other organisms are even more selective, such as those causing fruit rot of eggplant, and black rot and bull's eye rot of apples. Non-parasitic disorders that may cause heavy losses on the market are mechanical and chemical injuries, freezing, chilling, heat injury, immaturity, over-maturity, and various physiological conditions such as blossom-end rot and internal browning of tomatoes, scald of apples, and tipburn, russet spotting and rib discoloration of lettuce.

A wide variety of fresh fruits and vegetables is brought to market. In 1958, for example, 124 different kinds of produce, 173,246 carlot loads, were unloaded by rail, truck, ship or airplane in the New York City area. The variety of fruits and vegetables consumed in the area and their relative importance are shown in Table 1. The fresh fruits and vegetables unloaded at the New York market were grown in 43 states and 22 territories and foreign countries, including areas as distant as South Africa and Chile. The principal producing areas were California (34,045 carlots), New York (24,507 carlots), Florida (24,420 carlots), New Jersey (13,332 carlots), and Maine (10,347 carlots). These were followed by Texas (5,113 carlots), Arizona (5,041 carlots), Virginia (4,861 carlots), and South Carolina (4,370 carlots). The foreign origin of bananas often is listed as unknown and is not included.

Losses on the Market

Market losses are shared by growers, packers and shippers, storage and transportation companies, wholesale and retail distributors, processors, and consumers. Unfortunately, accurate data on the amount and causes of the losses in fresh fruits and vegetables occurring at all stages of marketing are relatively fragmentary.

[1] A review on the subject appeared in 1950 from this laboratory (Bratley and Wiant, Econ. Bot. 4: 177). The present report will cover some aspects of the problem not touched on previously with particular reference to the diseases now important on the market.

[2] Senior plant pathologist, Market Pathology Laboratory, U. S. Department of Agriculture, New York, N. Y.

Transit Losses. For 1958 rail carriers in this country reported loss and damage claims of $10,726,816 for 568,164 cars of fresh fruits and vegetables handled, an average of $18.88 per car. This included $1,346,492 for 163,869 cars of white potatoes; watermelons, $1,166,933 for 12,774 cars; cantaloups, $1,123,545 for 19,749 cars; tomatoes, $802,779 for 11,775 cars; lettuce, $792,425 for 64,845 cars; celery, $661,144 for 21,780 cars; grapes, $420,171 for 21,437 cars; oranges, $415,704 for 29,070 cars; plums, $372,444 for 4,247 cars; peaches, $314,596 for 7,657 cars; apples, $303,363 for 21,377 cars; pears, $266,443 for 9,078 cars; onions, $264,350 for 16,179 cars; and bananas, $208,412 for 73,660 cars. Carlot loadings of some commodities are much fewer in number than those just given but because of the perishable nature of the cargo show high loss and damage claims per car. For example, green peas, $99,716 for 642 cars, or $155.32 per car: asparagus, $77,762 for 1,022 cars; cherries, $50,182 for 829 cars; peppers $77,081 for 1,946 cars; snap and lima beans, $49,715 for 1,335 cars, and so forth.[3] These losses are for rail shipments only. Comparable data are not available from the trucking industry.

Losses During Processing. During processing, losses of edible substances suitable for human consumption have been estimated as 28% for apples, 19% cherries, 25% blackberries and related berries, 11% grapefruit, 12% lemons, 7% olives, 12% oranges, 28% peaches, 35% pears, 6% plums and fresh prunes (canned and frozen), and 15% strawberries. Similar estimates for various vegetables were 5% dry, edible beans, 15% lima beans, 10% snap beans, 10% beets for canning, 20% broccoli, 32% Brussels sprouts, 5% kraut cabbage, 20% topped carrots, 20% cauliflower, 28% corn (sweet, canned, and frozen), 10% pickle cucumbers, 20% peas (green, canned, and frozen), 10% processed potatoes, 30% spinach, 25% sweetpotatoes, and 10% tomatoes.[4]

Wholesale and Storage Losses. Deterioration of fruit crops during marketing was estimated for apples as 21%, apricots 1%, avocados 2%, cherries 2%, cranberries 12%, grapefruit 13%, grapes 9%, lemons 8%, limes 5%, oranges 15%, peaches 6%, pears 7%, plums 5%, prunes 6%, pomegranates 1%, strawberries 25%, and tangerines 16%. Similar estimates for losses on vegetable crops were artichokes 6%, asparagus 3%, snap beans 8%, lima beans 13%, beets 1%, broccoli 10%, Brussels sprouts 2%, cabbage 11.6%, carrots 4%, cauliflower 12%, celery 19%, cucumbers 2%, eggplants 5%, escarole 8%, lettuce 25%, cantaloups and muskmelons 13%, Honey Ball and mixed melons 4%, Honey Dew melons 2%, onions 25%, peas 5%, peanuts (selling point rejections) 10%, potatoes 16%, spinach 7%, and sweetpotatoes 19%.

Retail Losses. One source of information on retail losses from spoilage is the credit allowances on depreciated stock given to their retail outlets by chain store systems.[5] In 1956 the allowances made for vegetable losses by a large chain store system were asparagus 3%, string beans 7%, lima beans 6%, wax beans 6%, beets 6%, cabbage (old crop) 4%, cabbage (new crop) 6%, cabbage (red) 10%, carrots 4%, celery 8%, chicory 5%, corn 10%, cucumbers 4%, eggplants 6%, escarole 8%, kale 11%, mushrooms 8%, onions (late crop) 4%, onions (new crop) 6%, onions (Spanish) 6%, onions (white boilers) 8%, parsnips 4%, peas 7%, peppers 8%, potatoes (late crop) 4%, potatoes (new crop) 6%, rhubarb 5%, rutabagas 4%, spinach 11%, squash

[3]Association of American Railroads, Circ. FCD-1751, June 1959.

[4]U. S. Dept. Agriculture. Losses in Agriculture. A Preliminary Appraisal for Review. U. S. Dept. Agr., Agr. Res. Serv., ARS-20-1, 190 p. 1954.

[5]Unpublished data supplied by a chain store system, 1956.

4%, sweetpotatoes 4%, tomatoes (field) 7%, tomatoes (hot house) 6%, and turnips 4%. Losses allowed for fruits were apples 5%, apricots 4%, bananas 3%, cantaloups 4%, cherries 5%, cranberries 4%, grapes 7%, grapefruit 3%, Honey Dew melons 6%, lemons 3%, nectarines 5%, persimmons 4%, oranges 2%, peaches 4%, plums 4%, tangerines 4% and watermelons 3%.

Kitchen Losses. Losses that occur in the kitchen are probably the most costly because of the high value of the individual units purchased by the consumer. Losses include trimmings needed to remove unattractive, defective or decayed portions of fresh fruits and vegetables. There are few reports on losses in the kitchen. The last, obviously out of date and limited in scope, appears to be that by Miller who reported data supplied by 200 housewives in Knoxville, Tenn. during 1933 to 1935. Losses reported by the housewives were 4% for apples, avocados 0.2%, bananas 3%, beans 3%, cabbage 3%, cantaloups 0.5%, carrots 0.02%, cauliflower 1%, celery 7%, cranberries 12%, eggplant 0.5%, grapefruit 6%, lemons 5%, lettuce 10%, onions 10%, oranges 10%, peas 1%, peppers 7%, potatoes 8%, sweetpotatoes 12%, raspberries 8%, strawberries 15%, tangerines 5%, and tomatoes 7%.[6]

Classification of Market Diseases

The defects, blemishes and decays of fruits and vegetables on the market have been classified in a number of different ways. They have often been separated according to field or market origin. Such a classification, however, cannot be followed strictly because so many diseases occur both in the field and on the market. Furthermore, the quality and condition of fruits and vegetables at harvest determine to a considerable extent the diseases that develop on the market. Contrariwise, fruits and vegetables of equal quality and condition at harvest may develop considerably different amounts and kinds of market diseases depending upon handling practices after harvest. Probably the best way to illustrate the scope of market pathology and the variety of factors affecting fresh fruits and vegetables during handling, transportation, storage and marketing is a classification of market diseases based upon etiology. The etiological factors involved in market diseases include adverse temperature, humidity, and water conditions, poor soil conditions, genetic defects, mechanical injuries, chemical injuries, light injury, physiological disorders, and the specks, spots, and spoilage caused by parasitic organisms. Because of the large number of crops involved and the numerous factors causing disease, many types of disorders are encountered on the market. A few examples of each type of disorder will be discused with emphasis placed on those diseases causing losses on the market at the present time.

Freezing Injury. The freezing point of fruits and vegetables is lower than that of pure water. Thus cucumbers freeze at 31°F., asparagus at 30°, bananas 30°, beans 30°, lemons 28°, grapes 28° to 25°, and so forth. Although different commodities may have the same freezing point, some are much more readily injured by freezing than others. Turnips, cucumbers and lettuce all have a freezing point about 31°, yet turnips are fairly resistant to freezing injury, lettuce is less so, while cucumbers are injured readily at freezing temperatures. Tomatoes and parsnips have a freezing point of 30°, yet parsnips can be frozen and thawed several times without apparent injury whereas tomatoes are ruined after one freezing.

Fruits and vegetables frozen in the field or grove are found occasionally on the market. The condition is most often seen in the peeling of the epidermal layer of the wrapper leaves of western-grown

[6] Miller, P. R. Fruit and vegetable losses on market and kitchen caused by plant diseases. Pl. Dis. Rptr., Suppl. 88, 25 p. 1935.

lettuce. Injured citrus fruit may be found on the market following freezes in the South. Similarly, northern-grown potatoes frosted in the field may get to the market.

During marketing, freezing injury occurs principally in transit during wintertime. It is found most often in commodities having very low pulp temperatures as a result of holding in storage prior to shipment, such as Northwestern apples and pears, California grapes, and Maine potatoes. The addition of excessive amounts of salt to bunker ice to speed cooling or obtain lower transit temperatures sometimes results in freezing injury. In cherry and strawberry shipments freezing has occurred in crates next to cakes of dry ice used as a source of carbon dioxide to retard respiration, retain color, and reduce decay. In storage, freezing may occur in produce stacked adjacent to cooling coils. In wintertime, freezing may occur in non-insulated trucks and on unheated platforms and piers.

Fig. 1. Chilling injury of grapefruit.

Chilling Injury. Some fruits and vegetables are injured by chilling when held at temperatures above their freezing point but below the optimum temperature for their transit and storage. Chilling usually occurs on susceptible hosts in the range

Fig. 2. Blackheart of potatoes.

of 32° to 45°F., although bananas are chilled at temperatures as high as 53° to 56°F. Chilling injury may cause much damage to tomatoes, bananas, grapefruit, plums, sweetpotatoes, peppers and cucumbers. Symptoms of chilling injury include skin and pulp discoloration, pitting, failure to ripen properly, and increased susceptibility to decay.

When comparable lots of grapefruit are stored at 33°, 40° and 55°F., more severe pitting (chilling injury) occurs at 40° than at 33° and very little or none at 55° (Fig. 1). The same temperature relationship is seen in the development of membranous stain of stored lemons. Upon arrival at the market, green-wrap tomatoes chilled in the field or in transit usually exhibit no symptoms but in the ripening room may develop irregular color and show increased susceptibility to bruising injury and decay.

Although chilling injury is being investigated at the present time, its physiological mechanism is unknown. One theory postulates that cellular poisons,

such as volatile, hydrolyzed glucosides, are not detoxified at chilling temperatures and therefore accumulate. Another theory states ascorbic acid is destroyed at chilling temperatures with a resultant accumulation of quinones which causes discoloration. Chilling has also been shown to reduce oxidative and phosphorylative reactions by sweetpotato mitochondria. Another theory states that chilling injury results from the increased permeability of tissue cells.

Heat Injury, Sunburn and Sunscald. High temperatures and intense sunlight in the orchard and field may cause heat injury, sunburn, or sunscald of various fruits and vegetables, especially of apples, stone fruits, tomatoes, and white potatoes. In many cases the produce appears sound when harvested and the injury does not develop until sometime later. *Scald* of potatoes may occur in hot soils, after digging, in bagged tubers in the field, or in the top layers of loaded trucks waiting in line at packing houses. Usually some scald is seen each year on the market especially in the early crop of southern-grown potatoes. Scalded tubers may become wet and sticky in transit. They are often invaded by bacterial soft rot. *Sunscald* of plums is caused by a combination of high temperature and intense sunlight in the orchard. Apple *watercore* occurs mostly in growing areas with an arid or semi-arid climate where high daytime temperatures and intense sunlight prevail. Watercore is strictly an orchard disease and does not develop or increase during marketing. In mild form it may disappear after long storage. *Blackheart* of potatoes (Fig. 2) results from suffocation as a result of oxygen deficiency. In the field it sometimes occurs in waterlogged soils. It may occur also in deep piles in storage bins. On the market blackheart results most often from high temperatures generated by heaters placed in railroad cars to prevent freezing during winter. Hot water used to wash oranges may injure the fruit when the water tempera-

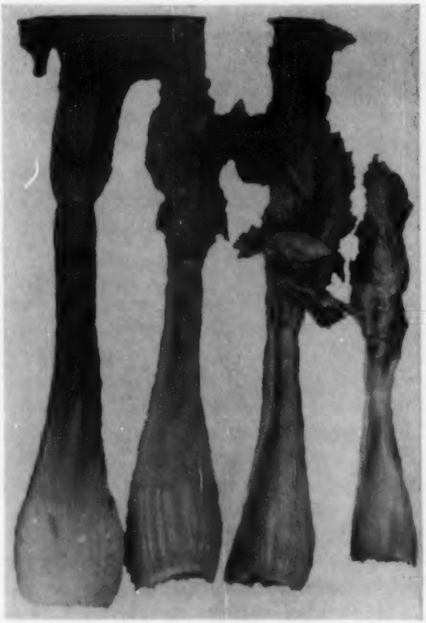

Fig. 4. Celery cracking.

Fig. 3. Tipburn of lettuce.

tures are too high or the fruit is exposed too long. Because it may take some time for the scalded condition to develop, fruit which is apparently sound when packed and shipped may arrive at the market with considerable skin breakdown.

Unfavorable Humidity Conditions. Some market losses are caused by *shrivelling* or *wilting* of fresh fruits and vegetables as a result of low relative humidity during storage or marketing. *Browning* of potatoes is a form of low humidity injury resulting in a discoloration of skinned areas of tubers exposed to the drying effect of winds in the field, packing shed, or moving cars, or trucks. Severe browning affects the market value of potatoes. Under certain conditions of low relative humidity plus rough handling potato tubers may devlop a condition called *thumb-nail cracking*. This injury looks as if potato handlers had stuck their finger nails into the tubers.

High relative humidity favors the development of surface molds and decay-producing organisms on fruits and vegetables. The recommended relative humidity for storage of sweetpotatoes is 80 to 85 percent. Stored at 95 to 100 percent relative humidity, sweetpotato roots were reported to develop an objectionable skin discoloration.

Adverse Water Conditions. Drought or excess rainfall may cause disease. During seasons of hot, dry weather *internal brown spot* of potatoes has proven a problem on the market because the disorder is difficult to detect without cutting the tubers. On the other hand, potatoes may develop *glassy end*, also called jelly end rot, when heavy rainfall follows a period of drought. Such tubers have a low specific gravity and are apt to decay in the field or market, as the affected tissue is invaded readily by various microorganisms. *Tipburn* is one of the more serious diseases of head lettuce (Fig. 3). Usually it cannot be detected without cutting open the head and often it is followed by bacterial soft rot. This physiological disorder occurs commonly when lettuce is making rapid succulent growth at the time the heads are maturing, especially when a cool, cloudy or rainy period is followed by sunny dry weather. *Creasing* of oranges is believed to develop in groves having an excess of water. The condition does not apparently increase after harvest.

Poor Soil Conditions. On the market, disorders arising from poor soil conditions are seen generally in the form of nutritional deficiencies. *Cork* of apples and pears, and a form of celery *cracking* (Fig. 4) results from boron deficiency. Some recent evidence indicates that *blackheart* of celery and *blossom-end rot* of tomatoes are forms of calcium deficiency. One form of *russet spotting* of lettuce is said to develop on excessively saline soils.

Genetic Defects. One of the factors to be considered in plant breeding programs is good shipping quality in fresh fruits and vegetables. Thin-skinned watermelons show more transit bruising than thick-skinned varieties. Some potato varieties, such as Sebago and Katahdin, develop less bruising than other varieties, such as Bliss Triumph. The genetic constitution of fruits and vegetables also affects their susceptibility to disease. Watermelon varieties such as Charlestown Gray which are susceptible to mycosphaerella rot are more of a problem on the market than more resistant varieties. Some of the genetic defects seen on the market are white potato tubers, the pulp of which was completely pink in color, and green-wrap tomatoes which ripened with large sectors failing to develop color.

Chemical Injuries. Chemicals and gases are used in the treatment of some fruits and vegetables to improve their appearance, lengthen their storage life or prevent decay. Improper applications of these materials may result in injury. In other cases, produce may be exposed accidentally to toxic materials, such as am-

monia gas escaping from refrigeration systems or to salts or fertilizers left in cars or trucks.

Fruits and vegetables injured by sprays or dusts used in the field for disease or insect control are found on the market; for example, apples burned by sulfur spray. Nitrogen trichloride gas used to prevent decay of green-wrap tomatoes may cause stem-scar injury. Sodium orthophenylphenate used as a dip to reduce decay may injure the skin of apples, pears, and citrus fruit. Skin breakdown may be caused by the methyl ester of naphthalene acetic acid used to prevent sprouting of potatoes in storage. Sulfur dioxide gas is used routinely in California during storage and prior to shipment of grapes to prevent decay. Injured grapes develop bleached areas usually around the cap stems and at skin breaks. Nectarines have been injured by accidental exposure to sulfur dioxide (Fig. 5).

Mechanical Injuries. Mechanical injuries occur in the field and at all stages of marketing. The final blows are delivered in the retail stores and in the kitchen. Fruits and vegetables which are overripe, overmature, frozen or very cold are very susceptible to mechanical injuries. Much of the decay that is found on the market starts in injured tissue. Mechanical injuries probably cause more losses on the market than any other factor. Some types of mechanical injury include soil scars on Honey Dew melons, hail injury of apples, waxy blister of tomatoes, bruising injury of tangerines, package crushing of grapefruit (Fig. 6), cutting and bruising, lidding injury of pears, scuffing of tomatoes, floor layer bruising of potatoes, box rubs of apples and pears, and shoulder bruises of tomatoes

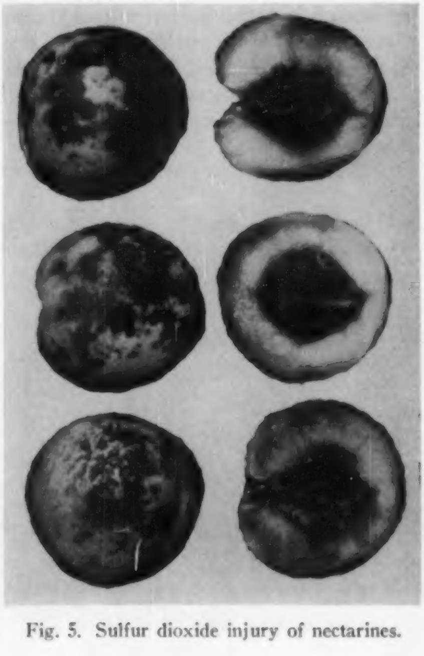

Fig. 5. Sulfur dioxide injury of nectarines.

Fig. 6. Package crushing of grapefruit.

Light Injury. Greening of potato tubers is objectionable to consumers. It may occur on exposed tubers in the field. On the market, tubers in bags of transparent film or in bulk displays in retail stores may be over-exposed to light.

Physiological Disorders. Numerous other non-parasitic troubles which are not as easily classified as those discussed above affect the quality and condition of fruits and vegetables. *Scald* is one of the

Fig. 7. Russet spotting of lettuce.

more serious storage and transit diseases of apples. In mild cases it appears only as a superficial skin discoloration, in very severe cases the underlying pulp may become necrotic. Scald usually develops after removal from cold storage. It develops more rapidly at high than at low temperatures. Delayed storage or a slow rate of cooling in storage increases susceptibility to scald. *Lime scald* is probably the most serious market disease of this fruit. This disorder appears to develop under conditions of storage at 40°F or lower, low humidity, and rough handling. Immature limes are especially susceptible. *Overmaturity* as a result of delay in harvest or *over-ripeness* resulting from lack of refrigeration or delay in marketing are market problems because overmature or overripe fruits and vegetables bruise easily and are susceptible to decay. *Russet spotting* (Fig. 7) and *rib discoloration* of head lettuce are now serious market problems as the discolorations are usually not seen until the heads are opened by the housewife. Both of the disorders apparently can be caused by a complex of factors. *Brown core* is a physiological disorder of some apple varieties such as McIntosh. The condition is associated with periods of cloudy, rainy weather when apples are maturing, and with long storage at 30° to 32°F. Brown core gets worse after removal of the apples f om cold storage. Large quantities of McIntosh are now stored in gas-tight, refrigerated warehouses where the atmosphere is controlled to about 2-3 percent oxygen and 5 percent carbon dioxide, at about 40°F. Under such controlled-atmosphere conditions brown core is largely controlled, and the apples can be stored about two to four months longer than in regular refrigerated storage. *Sub-oxidation injury* of McIntosh apples has developed when the oxygen content of controlled atmosphere warehouses has gone below the 2 percent level for a time. *Internal black spot* of potatoes is at present a problem in several producing areas. In some cases it has been associated with potash-deficient fields, but the addition of potash has only partially controlled the disorder. Rough handling and pressure bruises of cold tubers increase the incidence of black spot in susceptible lots of potatoes.

Fig. 8. Blue mold rot of lemon.

Parasitic Diseases

Parasitic fungi and bacteria may attack sound, healthy produce. On the market, however, most spoilage occurs on fruits and vegetables which have been predisposed to invasion by parasitic organisms as a result of mechanical injury, chilling, freezing, scald or other factors. When conditions of high temperature and humidity are present some of these parasites cause extensive rots. The most serious on the market are bacterial soft rot, blue mold rot, gray mold rot, watery soft rot, fusarium rot, rhizopus rot, alternaria rot, cladosporium rot and anthracnose rot.

Fungus Diseases. *Blue mold rot (Penicillium* spp.) causes very serious losses of citrus fruit (Fig. 8), stored apples and pears, plums, cherries and grapes.*Rhizopus rot* (*Rhizopus* spp.) is probably the most serious market decay of sweetpotatoes and strawberries. It may also be serious on peaches, plums, cherries, melons, and bananas. *Fusarium rot* (*Fusarium* spp.) causes important losses on sweetpotatoes, white potatoes, and melons. *Gray mold rot* (*Botrytis cinerea* Pers. ex Fr. and related species) causes probably the most serious decay of onions, artichokes, pears, and grapes. It is also important on apples, cherries, and green peas. *Watery soft rot* (*Sclerotinia sclerotiorum* (Lib.) D. By.) is an important factor in decay of snap beans, pears, lettuce, carrots, and celery. *Alternaria rot* (*Alternaria* spp.) may cause loss on lemons, melons, tomatoes, and apples. *Cladosporium rot* (*Cladosporium* spp.) is found frequently on cantaloups, grapes, stone fruits, and tomatoes. *Anthracnose rot* (*Colletotrichum* spp. or *Glomerella cingulata* (Ston.) Spauld. & Schrenk.) is destructive on cucumbers and watermelons, peaches, and various sub-tropical fruits as mangoes, avocados, and bananas. *Soil rot* (*Pellicularia filamentosa* (Pat.) Rogers) may occasionally cause much loss on tomatoes, snap and lima beans, turnips, rutabagas, and radishes.

The fungi discussed above attack a wide range of fruits and vegetables on the market. Other fungi attack only one or a few commodities on which, however, they may be highly destructive. *Phoma rot* (*Phoma destructiva* Plowr.) is common on southern-grown tomatoes. *Fruit rot* (*Phomopsis vexans* (Sacc. & Syd.) Harter) is the commonest cause of spoilage of eggplants. Black rot (*Endoconidophora paradoxa* (Dade) Davidson) causes more losses on bananas and pineapples than any other factor. *Late blight* (*Phytophthora infestans* (Mont.) D. By.) is important on tomatoes and potatoes. Other species of *Phytophthora* cause *brown rot* of citrus and *pink rot* of potatoes. *Leak* of potatoes is caused by related fungi (*Pythium* spp.). *Brown rot* (*Monilinia* spp.) is a serious orchard and market disease of peaches. *Stem-end rot* (*Diaporthe citri* Wolf or *Diplodia natalensis* P. Evans) is a serious disease of southern-grown citrus, but less important in California. *Bull's-eye rot* (*Neofabraea* spp.) is common on northwestern apples and pears.

Bacterial Diseases. *Bacterial soft rot* (*Erwinia carotovora* (Jones) Holland, *Pseudomonas marginalis* (Brown) Stevens, or related species) is one of the most common and serious market decays, especially on such leafy vegetables as lettuce, chicory, escarole, and spinach. It is also an important rot of potatoes, tomatoes, celery, cauliflower, and other vegetable crops (Fig. 9). *Ring rot* (*Corynebacterium sepedonicum* (Spieck. & Kotth.) Skapt. & Burkh.) of potatoes is a serious field disease and is occasionally seen on the market in table stock. Brown rot (*Pseudomonas solanacearum* E. F. Sm.) may be found at times in southern-grown potatoes. *Black rot* (*Xanthomonas campestris* (Pam.) Dowson) of cruciferous crops is common on the market. *Bacterial spot* (*Xanthomonas vesicatoria* (Doidge) Dowson) is the cause of an important blemish of tomatoes and peppers. *Scab*

Fig. 9. Bacterial soft rot of cauliflower.

(*Steptomyces scabies* (Thaxt.) Waksman & Henrici) is a common blemish of potato tubers. *Fireblight* (*Erwinia amylovora* (Burr.) Winslow *et al.*) is probably the most serious disease of pear trees but is seldom found affecting fruit on the market.

Virus Diseases. Virus infections of fruits and vegetables take place in the field and orchard. In some cases lesions become more pronounced after harvest, but usually virus-affected commodities are found on the market only because symptoms are internal or the external lesions are not readily visible at harvest or packing time. *Mottling* or *mosaic* caused by different mosaic viruses is most commonly seen on the market on tomatoes, beans and cucumbers. California-grown "White Rose" potatoes occasionally show *tuber necrosis* caused by the alfalfa mosaic virus (Fig. 10). Pronounced necrotic symptoms are produced on tomatoes by the spotted wilt virus or double-virus streak. The leaf-roll virus causes *net necrosis* of potato tubers.

Insect and Other Injuries

Insect injuries of fruits and vegetables are seen occasionally on the market in the form of worm injury of various vegetables and scale insects on citrus and nectarines. The bronzing of citrus fruit usually results from the russeting caused by rust mites. Nematodes may cause much damage in the field, but on the market about the only disease caused by them is seen occasionally in potatoes affected by the root knot nematode.

Fresh fruits and vegetables may be affected by environmental, chemical, mechanical or parasitic agents which cause considerable loss in the marketing channels. Determination of the causes of the defects, blemishes and decays of fruits and vegetables is the first step to reduce market losses. The methods of control to prevent or reduce spoilage are not discussed in the present report. They include the shipment of high quality produce protected by proper refrigeration, handling and loading methods and by containers designed to reduce mechanical injuries by proper marketing, and by the use of safe and approved chemical treatments. A study of the causes of market disorders and the methods for their control is necessary to ensure a supply of high quality fruits and vegetables in the marketplace.

Fig. 10. Tuber necrosis of potato.

TABLE I

FRESH FRUITS AND VEGETABLES UNLOADED IN THE METROPOLITAN NEW YORK CITY MARKET IN 1958.[1]

Rank	Commodity	Carlots[2]
1	Potatoes	25,284
2	Bananas	14,781
3	Lettuce	11,758
4	Apples	8,936
5	Tomatoes	7,503
6	Oranges	7,082
7	Onions	6,970
8	Peaches	6,382
9	Watermelons	5,612
10	Grapes	5,395
11	Cabbage	5,241
12	Celery	4,659
13	Cantaloups	4,608
14	Corn	4,090
15	Grapefruit	4,023
16	Cucumbers	3,285
17	Carrots	3,167
18	Pears	3,132
19	Beans, Snap	2,581
20	Peppers	2,404
21	Cauliflower	2,229
22	Sweetpotatoes	2,200
23	Lemons	2,070
24	Honey Dew Melons	1,946
25	Plums-Prunes	1,758
26	Pineapples	1,587
27	Spinach	1,357
28	Mushrooms	1,196
29	Escarole	1,129
30	Squash-Pumpkins	1,048
31	Asparagus	1,043
32	Plantains	1,009
33	Strawberries	989
34	Broccoli	975
35	Turnips-Rutabagas	806
36	Eggplant	693
37	Tangerines	626
38	Radishes	621
39	Cherries	544
40	Collards	535
41	Blueberries	529
42	Broccoli Rabe	522
43	Endive	466
44	Peas, Green	454
45	Beets	434
46	Nectarines	422
47	Parsley	353
48	Garlic	348
49	Green Onions	297
50	Arum	276
51	Spanish Melons	233
52	Rhubarb	222
53	Artichokes	219
54	Dandelion	219
55	Avocados	209
56	Dasheens	200
57	Kale	198
58	Yams	189
59	Anise	156
60	Brussels Sprouts	150
61	Mustard Greens	140
62	Okra	113
63	Shallots	97
64	Leeks	91
65	Beans, Fava	75
66	Chinese Cabbage	74
67	Swiss Chard	74
68	Endive-Witloof	68
69	Sorrel	64
70	Apricots	60
71	Turnip, Tops	54
72	Peas, Field	53
73	Parsnips	51
74	Limes	49
75	Cipolino	47
76	Beans, Lima	46
77	Mangoes	42
78	Cranberries	41
79	Pomegranates	39
80	Figs, Fresh	35
81	Peas, Pigeon	35
82	Celeriac	34
83	Persimmons	33
84	Persian Melons	29
85	Apio	25
86	Prickly Pears	25
87	Culantro	24
88	Soup Greens	22
89	Dill	21
90	Chayotes	20
91	Watercress	20
92	Dates	19
93	Black & Dewberries	18
94	Crenshaw Melons	18
95	Hanover Salad	18
96	Kohlrabi	17
97	Chicory	15

[1]Data from U. S. Dept. of Agriculture, Market News Service, New York City, Unloads of Fresh Fruits and Vegetables, 1958. Figures for carlot loadings reported as mixed fruits and vegetables, etc., are not listed. Many less-than-carlot-loads are not reported with the result that some commodities, e.g., gandules, come in greater quantities than indicated. Nine other commodities as horseradish roots, do not appear in the table even though small quantities are generally available on the market.

[2]The weight of a carlot load varies according to the commodity, type of container, producing area, variety or season shipped, type of carrier, and other factors. Some representative weights for carlot loads are asparagus, 18,000 lbs.; cabbage, 25,000 lbs.; carrots (topped), 30,000 lbs.; grapefruit, 40,000 lbs.; onions, 27,500 lbs.; oranges, 45,000 lbs.; potatoes, 40,000 lbs.; sweetpotatoes, 25,000 lbs.; tomatoes, 27,000 lbs.; and watermelons, 36,000 lbs. Recently, the rail carriers have allowed lower rates per package for heavier loads; consequently, there has been an increase in the weight of some carlot loadings.

TABLE I—Continued

Rank	Commodity	Carlots[2]	Rank	Commodity	Carlots[2]
98	Casaba Melons	14	107	Raspberries	5
99	Ginger Root	14	108	Papayas	3
100	Olives, Fresh	14	109	Quenapas	3
101	Basil	10	110	Chives	2
102	Rappini	10	111	Breadfruit	1
103	Field Cress	9	112	Honey Ball Melons	1
104	Beet, Tops	8	113	Currants	1
105	Cardoon	7	114	Gandules	1
106	Cabbage Sprouts	5	115	Honey Berry	1

Utilization Abstract

The Spanish olive industry. In Spain, thousands of hectares are devoted to olive growing, and export of olives is worth $20,000,000 annually. The olive tree is an evergreen that produces small, white flowers in spring and ripe fruit, the black olives of commerce, in October. Most olives are harvested in September when they are yet green. In natural state, olives are bitter and so must be cured to make them fit for eating. The fruits are picked and inspected in the orchard, transported to a packing station, placed in cement vats containing 2.5 percent caustic soda, and soaked for 14 hours. They are then washed, transferred to casks, and covered with 8 percent brine. The casks are placed in the sunshine for fermentation to occur, the bung being opened to allow scum to flow out. Fermentation takes about 30 days, during which time the bitter flavor is removed and lactic acid is produced, with a resulting pH of about 4. The pH must be carefully controlled to prevent growth of undesirable microorganisms. When fermentation is complete, the olives are inspected, graded, and finally placed in brine in clean casks and stored until required for use. In the production of stuffed olives, cured olives are pitted one at a time with a hand-operated plunger and then filled by hand with strips of brine-preserved red pimiento. Stuffed olives are returned to casks and stored in brine. For production of oil, ripe olives are harvested, taken to a factory, and milled or crushed. The pulp is pressed to extract the first quality oil, which is then filtered and packed for market. A second quality oil, obtained by further pressing, is completely refined before being placed on the market. Valuable by-products are glycerine and fatty acids derived from olive pulp. In Spain, olives are eaten at almost every meal, and olive oil is much used for cooking and salads. The oil forms a major part of the fat in the Spanish diet. *E. A. M. Bradford. Food* **28** *(335): 285-288. 1959.*

JOHN W. THIERET

A Phytochemical Study of Eight Mexican Plants

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Introduction

Mexico is a land with a great variety of native plants and, long before Columbus, the Aztecs and other Indian nations found many of them of medicinal value. Their knowledge of them was preserved orally. When the Spaniards came, an Indian scholar, Martin de la Cruz (1) wrote the first compilation on native medicinal plants. Later (in 1570), Francisco Hernández, Physician of the King of Spain, traveled for five years throughout Mexico collecting medicinal plants. Later he wrote several manuscripts concerning them (2) which, after many adverse circumstances, were partially published in 1651.

Other Spanish physicians and pharmacists continued the search for the medicinal plants used by the several Indian nations for two centuries. During the last quarter of the 19th century, the Mexican government established a research center, the "Instituto Médico Nacional," in which a systematic study of the native medicinal plants was undertaken. A botanist collected and classified the plants, a chemist prepared extracts and started research on the active principles, a physiologist assayed the extracts on animals, and the physicians tested them on the inmates of a hospital for poor people. The results of this research, which was discontinued in 1912, were reported in two journals: "El Estudio" from 1889 to 1893, and the "Anales del Instituto Médico Nacional" from 1894 to 1912. More recently, this kind of research has been continued in the schools of pharmacy and chemistry of Mexico; a good review of the work is given by Martínez (3) and a very complete bibliography on the subject has been published by Guerra (4). As a highlight on the Indian knowledge of plants may be mentioned their use of *Rauvolfia heterophylla*, from which reserpine has been isolated (5), for the same ailments for which this new alkaloid is actually prescribed.

For the present study, reported medicinal and toxic Mexican plants were selected because it was found that they had not been subjects of chemical investigation. The plants were collected in the states of Nuevo León and Chihuahua, México.

From the different methods for extraction of active principles from plants (6), we chose to extract the plant-material exhaustively and successively in a Soxhlet apparatus with petroleum ether, ethanol, and water. The solvent was evaporated on a steam bath, the last portions of it under reduced pressure. All the extracts were assayed for alkaloids, saponins, flavones, and tannins, as reported by Wall (7, 8). An aliquot of the ethanolic extracts was also hydrolized with hydrochloric acid as reported by Scott (9), and the hydrolized residue was again assayed for alkaloids, with phosphomolibdic acid, Meyer's and Dragendorff's reagents (10). Only when both procedures gave positive results, was the presence of alkaloids accepted.

Experimental

The plant subjects of this phytochemical survey were:

CADILLO (*Xanthium orientale* L.), collected in Villa García, Nuevo León, México.

QUELITE (*Amaranthus retroflexus* L.), collected in Apodaca, Nuevo León, México.

HELECHILLO (*Notholaena sinuata*, var. *cochisen-*

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sis (Goodding) Weatherby, collected in Villa García, Nuevo León, México.

CANELO (*Melia azederach* L.), collected in Allende, Nuevo León, México.

ANACAHUATA (*Cordia boissieri* A. DC.), collected in Apodaca, Nuevo León, México.

SANGRE DE DRAGO (*Jatropha spatulata* DC.), collected in Apodaca, Nuevo León, México.

SOSO (*Agave schottii* Engelm.), collected in Creel, Chihuahua, México.

HIERBA LECHOSA (*Asclepias erosa* Torr.), collected on the National Highway, close to Monterrey, Nuevo León, México.

The plants were collected and identified by one of us (P. R.); and a specimen of each plant is deposited in the herbarium of the Department of Botany of the I.T.E.S.M., Monterrey.

General procedure for the extraction: A mixture of roots, stems, leaves, and if possible, flowers and fruits, weighing 100-150 grams was dried, then powdered. The powder was extracted exhaustively in a Soxhlet apparatus first with petroleum ether (boiling point 30-60°), then with ethanol, and finally with water. Each extract was worked and assayed separately. The solvent was evaporated on a steam bath, and the last portion of the ethanolic extracts, according to the method of Scott (9), was refluxed with hydrochloric acid 2N, then treated with concentrated sodium hydroxide. The alkaline material was extracted with ethyl ether, and the residue obtained from the ethereal solution was assayed for alkaloids. The results obtained are summarized in the accompanying table.

TABLE

RESULTS OF THE PHYTOCHEMICAL SCREENING OF EIGHT MEXICAN PLANTS[1]

Botanical Name	Parts of the plant used[2]	Extracts from[3]	Alkaloids tests[4] PM	M	D	Saponins	Flavones	Tannins
Xanthium orientale	l, s, f	PE	†	–	–	–	–	–
		Et OH	††	††	††	–	††	–
		W	†	–	†	–	††	†
Amaranthus retroflexus	l, s	PE	–	–	–	–	–	–
		Et OH	–	–	–	†	–	†
		W	–	–	–	–	–	–
Nothalaena sinuata var. *cochisensis*	l, s	PE	–	–	–	–	–	–
		Et OH	–	–	–	–	–	–
		W	–	–	–	–	–	†
Melia azederach	f	PE	–	–	–	–	–	–
		Et OH	–	–	–	–	–	–
		W	††	††	††	–	–	–
Cordia boissieri	l, s	PE	–	–	–	–	–	–
		Et OH	–	–	–	††	–	–
		W	–	–	–	††	–	–
Jatropha spatulata	l, s	PE	–	–	–	–	–	–
		Et OH	–	–	–			
		W	–	†	†			
Agave schottii	s, r	PE	–	–	–	–	–	–
		Et OH	†	†	–	††	–	–
		W	†	†	–	††	–	–
Asclepias erosa	s, l	PE	–	–	–	–	–	–
		Et OH	–	†	†	–	†	–
		W	–	†	†	–	†	–

[1] †, slight precipitate or hemolysis
††, medium precipitate or hemolysis
†††, heavy precipitate or hemolysis

[2] l = leaves, s = stems, r = roots, f = fruits

[3] PE = petroleum ether, Et OH = ethanol, W = water

[4] PM = phosphomolibdic acid, M = Meyer's reagent, 4 = Dragendorff's

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BOOK REVIEWS

The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. Vol. 5 (Raw Materials): H-K. B. N. Sastri, Chief Editor. New Delhi: Council of Scientific & Industrial Research. xxviii + 332 + xii pp. illus. 1959.

Volume 1 of George Watt's classic *A Dictionary of the Economic Products of India* appeared in 1889; the last volume was published seven years later. Volume 1 of *The Wealth of India,* worthy successor to the Watt *Dictionary,* appeared in 1948; with the publication of volume 5, *The Wealth of India* is only half completed, eleven years after its inception. To those of us who regard *The Wealth* as one of the best sources of information on economic plants, the thought of waiting possibly another decade for the final volume is disheartening.

Volume 5 carries on the high standard of excellence set by its four predecessors. It contains 380 entries, of which 370 are on plants, 7 on animals, and 3 on minerals. Major articles, with the number of pages spanned by each, are: Helianthus (11), Hevea (30), Hibiscus (24), Hordeum (15), Indigofera (12), Insects (53), Ipomoea (18), Iron Ores (15), and Jasminum (14). The articles review much pertinent literature—data of universal interest and use—and contain many original observations on Indian aspects of the various subjects. The volume contains 169 text figures and 16 plates, 6 of them in color (plate X was missing from the review copy sent to ECONOMIC BOTANY). Most of the photographic reproductions are of fair to average quality. An index brings the volume to a close.

The Chief Editor of *The Wealth of India* is "keenly conscious of the need for completing the compilation of the remaining volumes expeditiously." The users of this outstanding reference work are also conscious of this need and hope that publication of the final sections can be accelerated. We do not wish to wait until 1970 before we are able to turn to *The Wealth of India* for information on Zea, Zingiber, and Zizyphus.

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Vegetable Diseases and Their Control. C. Chupp and A. F. Sherf. 693 pp. illus. The Ronald Press Company, New York, 1960. $12.00.

This book of nearly 700 pages is a manual of diseases of vegetable crops. It is purposely written in nontechnical language in order to be of maximum benefit to those concerned with disease diagnosis and control. The senior author has been uniquely success-

ful as an Extension Specialist in vegetable diseases, and this book draws not only from the literature but from a rich background of experience. The book is organized into 22 chapters, including five chapters on subjects of general interest such as damping off diseases, minor element deficiencies, nematode diseases, and soil sterilization. Sixteen chapters are devoted to diseases of the various vegetable crops. Some serious objections are to be raised about the organization of the text. It is unfortunate that a book on vegetable diseases has no treatment of potato diseases. It does not seem justifiable to omit one of our most important vegetable crops on the assumption that potato diseases are so complex as to require a separate study. Also, unrelated vegetable crops are treated under the same chapter, for example, "Diseases of beets, carrots, and chicory" and "Diseases of eggplant and lettuce." This grouping would imply to many readers that these crops have diseases in common or that they have similar culture. Such is not the case. The 179 black and white illustrations deal for the most part with symptoms. Many of these illustrations are good but some are poor. This book will be very valuable to county agents, agricultural teachers, and growers, but its use as a source book for research persons will be limited because of significant omissions and erroneous implications. For example, in the treatment of bacterial soft rot of vegetables little attention is given to the role of enzymes in pathogenesis and the list of references does not include the truly classical paper of L. R. Jones.

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Bananas. N. W. Simmonds. xvi + 466 pp.; VI color, 87 black and white photographs; 55 tables; 54 figures; 5 indices. Longmans, Green and Co. Ltd., London. 1959. 45/- net.

This is the fifth book in a series on tropical agriculture published with active encouragement of the Colonial Advisory Council of Agriculture, Animal Health and Forestry. Others in the series already published include: *Rice*, 3rd edition, by D. H. Grist; *Cocoa*, 2nd edition, by D. H. Urquhart; *Tea*, by T. Eden; *Introduction to Animal Husbandry in the Tropics*, by G. Williamson and W. J. A. Payne.

This is not a romance of tropic life for Sunday afternoon reading. It is solid and factual, aimed at a specialized audience. As stated in the preface, this audience is a heterogeneous one, composed of research workers on scientific aspects of the crop, the government agricultural officials, and the planter. This is the basis for its merits and failings, as the coverage must be diverse and in some cases superficial. Chapters include the following subjects: botany, from systematics through developmental correlations; classification of cultivars; climates and soils; planting and management; harvest, transport, and ripening; chemical composition and utilization of the fruit; production and economics; history; pests; diseases; breeding. Each chapter is followed by a summary and a list of pertinent references. The reproductions, particularly the color plates, are very good.

The botanical section is thorough but terse; more line illustrations of the structure would have been welcomed. Notable throughout the text, but particularly here, is an admirable lack of restraint in bringing out points of dispute or ignorance; enough for many a graduate student and research worker.

The chapters on classification of cultivars, with lists, descriptions, distribution, and usage are worthy of particular mention. The system of classification appears to be well conceived and worked out, and should be invaluable in identifying clones, both by the planter and the breeder. The scoring system used as an aid for identification appears ideally suited for analysis by "pictorialized scatter diagrams" (à la Edgar Anderson), which might give a more comprehensive presentation.

The three major diseases are treated in detail, the minor ones summarized, the only method possible in a book of this sort, particularly as there are other adequate references. The control of Bunchy Top disease in Australia summarized here is an example that should be read by all those who question the effectiveness of plant quarantine.

The major pests are covered in condensed accounts, the minor ones in an annotated list, unavailable elsewhere. The chapter on

breeding should be of interest to those in any breeding program, particularly the aspects of program orientation. The subjects in other chapters are dealt with briefly or at length, following the needs of this book. Distribution and marketing are not within the scope of this treatment.

Lastly, the general, personal name, place name, clone name, and scientific name indices will be of invaluable aid to researchers.

S. S. TILLETT

Grasslands. Edited by H. P. Sprague. 406 pp. illus. Publication No. 53 of the American Association for the Advancement of Science, Washington, D. C., 1959. $8.00.

"Grasslands" is a collection of papers presented at a symposium at the New York meeting of the American Association for the Advancement of Science in 1956. It contains contributions from 44 authors and includes five papers on sciences associated with grasslands, five on forage production in humid regions, four on the engineering aspects of grassland agriculture, four on forage utilization, four on evaluation of nutritive significance of forage, five on climatology of grasslands, four on ecology, and five on range management.

In general, the papers are well written and well documented, although some appear to have little to do with the study and management of true grasslands. As is to be expected, contributions from so many authors lead to widely divergent expressions of ideals. For instance, Mr. Harlan states of climax plants: "Few plants of this class are important forages"; in contrast, the range condition classes of Mr. Dyksterhuis are based on the percent of potential or climax vegetation for a site.

The section on sciences in support of grassland research contains five papers dealing with such varied topics as microclimate, genetics, pathology, physiology, and the effects of mineral content of the soil on nutritive content of the forage produced. The impact of grasslands on the economy of the corn belt and the northeast, and the problems of insect and disease control are stressed in the section of forage production in temperate and humid regions. The section on engineering contains papers on equipment for establishment of grassland and for harvesting, handling, preserving, storing, and feeding the produce from pastures.

The portion of the book dealing with utilization of forages deals almost entirely with nutrition problems on improved pastures, and does not contain a single paper on utilization of native grassland. Likewise, the section on forage evaluation is confined primarily to pasture or dairy studies. Although the principles presented are sound, the examples used are not always from grassland situations.

The final three sections, grassland climatology, ecology of grasslands, and range management, more nearly support the general title of "Grasslands" and come closer to describing the dynamics of true grasslands than do other sections of the book. A few papers in these sections seem somewhat out of place. It is disappointing that Mr. Dyksterhuis's fine paper on ecological principles in range evaluation is represented only by a precis.

This book contains a wealth of information. Some papers in it should appeal to most everyone in agronomy, botany, or range management. Although the book is a valuable contribution, it seems unfortunate that the title "Grasslands" should have been applied to it. It would be almost impossible to live up to such an all inclusive title in so short a space.

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Manioc in Africa. William O. Jones. Stanford University Press, 1959. ix + 315 pp. $6.75.

This book is of outstanding value. It is the first over-all summary of our knowledge of *Manihot esculenta* in Africa, and anyone who has attempted to find information on production, distribution, use, and importance of this food plant in Africa will be relieved to find a source book of such depth and orderliness. In ten chapters, Dr. Jones has covered the history of manioc in Africa, the various areas of cultivation, the food value, the agricultural and the economic significance of this crop. There are appendices, tabular material, maps, and exhaustive bibliographies.

Several controversial issues have been adequately reported, both sides being well presented. Perhaps the most important of these are: does the crop exhaust the soil excessively? are there any differences (other than environmental) in the varieties of manioc in their production of cyanogenetic glucosides? are the roots good sources of vitamins? etc. Most of these controversies are discussed in chapter 1—Studies of the plant, its characteristics and culture. It is obvious that this is the least known aspect of the studies of manioc.

As a student of the classification of the species of *Manihot,* I am sorry to see the acceptance of the epithet *M. utilissima* (p. 6) as the name for the food-producing plants of this genus. The author of this name (Pohl, Plantarum Brasiliae) intended to separate bitter varieties from sweet. Later authors have found that it was difficult to maintain two species (as pointed out by Jones) and have considered all manioc as one species. However, the acceptable name is not *M. utilissima,* but an earlier name, *M. esculenta* Crantz. Whether the epithet *M. esculenta* will stand or fall is not yet decided. Intensive study of the cultivated and wild species of *Manihot* in the areas of origin in South America must be made to decide the correct biological relationships. Authors who pass over this problem do a disservice to all concerned because without the correct names, the relationships among the plants remain obscure. I am not certain that *Manihot palmata* of Mueller Argoviensis is synonymous with *M. dulcis* (J. F. Gmel.) Pax, or with *M. utilissima* Pohl.

Jones' discussion of the physical environments (chapter 2) in Africa where manioc is grown is a tremendous contribution to anyone interested in the regions south of the Sahara and north of the Zambezi. He divides the area into three major regions, based on differences in geography, climate, and the social and historical organization: the Congo, Guinea (or West Africa) and East Africa. His studies of the population in these areas also provide a fund of useful information.

In Chapter 10 Dr. Jones makes some very pertinent remarks on the place of manioc in a developing economy. He points out that, because of manioc's competitive advantage, production will probably increase as African economies become wealthier and more efficient. Furthermore, he has some very significant comments in rebuttal to those who have belittled manioc because of its low protein content. He points out that merely because the plant has nothing but starch it must not be considered bad in the diet, because every diet must contain some starch. "In fact, it is an old adage of nutritionists, or at any rate it should be, that there are no bad foods, only bad diets." (p. 273)

It is quite evident in this last chapter that Dr. Jones, who has done an excellent job of objective reporting of the scattered information on manioc in Africa, has become a champion in its favor.

DAVID J. ROGERS
New York Botanical Garden

Advances in Applied Microbiology. Volume I. Wayne W. Umbreit, *ed.* Academic Press, N. Y. & London, 1959. xi + 304 pp. $9.50.

The present book is the first volume in a new series, "Advances in Applied Microbiology," under the editorship of Wayne W. Umbreit. A good beginning has been made. Eleven articles are included, the subjects of which are sufficiently diverse to provide something of interest to every reader concerned with applied microbiology.

The present importance of the fermentation industry is emphasized by the fact that seven of the reviews deal with fermentations or the products thereof. The review by Shuko Kinoshita on the production of amino acids by fermentation processes brings to the reader the results of original research carried out in Japan. The use of antibiotics for the control of contamination in various fermentations is discussed by Milos Herold and Jan Necásek of the Antibiotics Research Institute in Czechoslovakia. The reviews just named exemplify a policy, stated by the editor in the Preface, of making available information not readily accessible elsewhere. An interesting review concerned with the growth of the higher fungi in large tanks is contributed by Radcliffe F. Robinson and R. S. Davidson. The excellent discussion by Philip Gerhardt and M. C. Bartlett of continuous industrial fermentations is highly

recommended for reading by anyone interested in the theory, as well as the practice, of continuous fermentation. Progress made in discovering the metabolic pathways leading to the synthesis of penicillin is well summarized by Arnold L. Demain. The microbial synthesis of Cobamides is discussed by D. Perlman in a well-organized article. A statement of the present status of antibiotics in the control of plant disease by David Pramer completes the list of reviews devoted to fermentations and their by-products.

The four articles not yet mentioned are: *Germfree Animal Techniques and their Applications* by Arthur W. Phillips and James E. Smith; *Factors Affecting the Antimicrobial Activity of Phenols* by E. O. Bennet; *Insect Microbiology* by S. R. Dutky, a survey of diseases of insects; and *Preservation of Food and Drugs by Ionizing Radiations* by W. Dexter Bellamy.

ALMA W. BARKSDALE
New York Botanical Garden

Enciclopedia Argentina de Agricultura y Jardineria. Lorenzo R. Parodi. 946 pp. 252 pls. Acme, Buenos Aires, Argentina. 1959. $28.50.

Here is a work of rare value to the student of South American plant life, either horticultural or agricultural. Its coverage of Argentine plants includes cereal, fruit, ornamental, herb, vegetable, feed, and forest plants. More than 2,700 species and many varieties are described and 600 are illustrated by pen and ink drawings. Though the descriptions are in Spanish, they should not be difficult for the student trained in botanical terminology to follow. Illustrations are distinguished both for their clarity and artistic appeal. Apart from the frontispiece, all are black and white. The work is organized methodically, with keys leading from orders to families, families to genera, and genera to species. Varieties, where they are important, are listed and described under species. Full description is supplied at each step.

Of interest to both student and traveler are the listings of Spanish common names in Argentine usage. Origins of non-native plants are given and distribution of species is supplied. Usages and propagation methods are also discussed. The book should be useful throughout the Spanish-speaking world since too few such thorough and systematic works on plants have been published in that language. It is unusual both for its completeness and accuracy.

The editor, Lorenzo R. Parodi, is a professor of agricultural botany at the University of Buenos Aires. The pen and ink drawings are the work of Iginio Lona, a specialized plant illustrator. Other outstanding Argentine botanists assisted Prof. Parodi in the preparation of the text.

PHIL CLARK
Mexico, D. F., Mexico

Industrial Gums. Polysaccharides and Their Derivatives. Roy L. Whistler and James N. BeMiller. 766 pages. Academic. Press. 1959. $25.00.

This treatise emphasizes the practical aspects of gums, both for industrial and laboratory use. A limited amount of chemistry is included, but for chemical aspects of the subject, the editor suggests the companion volume POLYSACCHARIDE CHEMISTRY by Roy L. Whistler and Charles L. Smart.

The book consists of 31 chapters, each by a different author, all but a few of whom have industrial rather than academic connections. The first chapter discusses gums in general and their suitability for various applications from the point of view of properties and cost. Each of the other chapters deals with a different gum. Included are agar, Danish agar, algin, Carrageenan, Fucoidan, Laminaran, "some lesser known seaweed extracts," chitin, gum arabic, corn hull gum, larch arabogalactan, gum ghatti, guar gum, gum Karaya, locust bean gum, pectin, quince seed, psyllium seed and flaxseed gums, tamarind, ti, gum tragacanth, wheat gums, dextrans, methylcellulose, hydroxyethylcellulose, ethylhydroxyethylcellulose, sodium carboxymethylcellulose, starch amylose, starch amylopectin, starch dextrins and starch ethers. In general, for each gum, information is given on source, methods of processing, types or grades, properties, particularly in relation to possible applications and uses. Often, useful tables and graphs are included and consistently there are a generous number of references to original papers. The index supplies what would otherwise be a lack intrinsic in the arrangement of the book, namely a convenient way of selecting a gum for a particular use with-

out looking through all the chapter subheadings. Included in the index are such references as "adhesives," "bakery products," "ceramics," "confectionary," "cosmetics," "emulsifiers," "films," "gels," "paint," "paper," "pharmaceuticals," "textiles," and other possible fields of application.

INDUSTRIAL GUMS appears to be an excellent reference book, both in that it is a source of much detailed information between its own covers, as well as through its chapter bibliographies. In spite of this, or perhaps because of it, the book makes pleasant reading. It does not give the overcondensed, crowded, and hurried feeling of many books of this type. The style is generally clear and straightforward, not involved. Most of the authors have taken time to mention interesting, though not necessarily utilitarian aspects of their subject, including historical or even legendary background material.

MARJORIE ANCHEL
New York Botanical Garden

Agricultural Botany. N. T. Gill and K. C. Vear. viii + 636 pp., 262 figs. G. Duckworth & Co. Ltd., London (Macmillan distrib.), 1958. 63 shillings.

This is the successor to Percival's classic text with the same title and same publishers, the 8th and last edition of which appeared in 1936, but it is by no means just another edition of that work. Nearly half of Percival's book was a general introduction to plant morphology and physiology. The present book happily leaves the elementary background to standard botany texts and is therefore free to deal more fully and directly with agricultural botany.

After a substantial section on theory and methods of plant breeding and quality seed production, the bulk of the book is devoted to individual species and varieties of crops, weeds, and diseases, systematically arranged. Each is characterized by adequate descriptions and sketches; brief attention is given to origin and history, and fuller attention to ecology, economics, and methods of cultivation or control. Throughout there is a nice blending of concrete information and general principles. One can learn not only that clovers are readily cross-pollinated and how to wash bees for controlled clover pollination, but also the genetic consequences of cross-pollination in plant evolution in general. One learns that certain kinds of pastures are established more economically with costly seed obtained locally from old pastures than with inexpensive commercial seed of the same species and one also learns why this makes sense in terms of ecotypes and selection processes.

The book focuses always on agriculture in Britain. The kinds of plants selected for discussion, the information on ecology and management, even the terminology, all reflect this limitation, so the book is unsuitable for general use as a text. This does not mean that it is without value outside the British Isles. Anyone with an active interest in plant-man interrelationships will find it a mine of accurate information, much of which is not readily available elsewhere and all of which is well presented. The authors are informed and up to date in both academic and applied botany and their presentation has the simplicity that comes not from innocence but from wisdom.

JONATHAN SAUER
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Indian Uses of Native Plants. Edith Van Allen Murphey. Privately printed, viii + 72 pp., illus., 1959. (Price varies, $2.50-$3.50.)

This publication promises well: the author spent extended periods with Indian groups throughout the West; professional botanical assistance was utilized for species identifications or determinations. With great devotion she has investigated basketry, foods, beverages, recipes, "feasts," fish poisoning, medicines, dye plants, tobacco, and certain nonbotanical topics, such as game animals and tipis. Despite her diligence, however, the author leads us into a never-never land. The booklet is strangely and incoherently organized, and its merits are vitiated by numerous faults.

The author sometimes merges data from more than one botanical and Indian entity. For example, she uses the name *Cogswellia Cous* for the first food plant she discusses (pp. 12-13); she describes it as having white or pale lavender flowers and a rootstock with a series of large, round tubers one above the other. The name is a synonym for *Lomatium cous* (S. Wats.) C. & R,. which has yellow flowers and a single (often elongate) tuber. The white flower color may be based on

Lomatium canbyi C. & R. and the lavender variant on *L. gormanii* (Howell) C. & R., or on some tuberless *Lomatium*. The moniliform root system may have been derived from *Lomatium canbyi* C. & R.—which rarely has multiple tubers—or from L. *geyeri* (S. Wats.) C. & R. or *L. farinosum* (Geyer) C. & R., whose tubers are too small to fit her description. A Nez Perce name, "Cous," and Warm Springs Indian utilization data have also been combined. The ever-resourceful Sacajawea was said to have called this "interesting plant" to the attention of Whites.

Names appear to have caused the author trouble in various ways: because certain food plants are called "wild celery," she tentatively assigns them (p. 71) to *Apium*, the genus to which cultivated celery belongs. Her botanical designations, which are given without authorities, are frequently those in use in the early decades of this century. Because of their ethnobotanical importance, and the reviewer's interest in the family, her names for members of the Umbelliferae were examined. In addition to *Cogswellia* and *Leptotaenia* for species of *Lomatium*, she uses *Carum Gairdneri* for *Perideridia gairdneri* (H. & A.) Math. and both *Washingtonia* and *Osmorhiza* for species of the latter. She uses *Sium cicutaefolium* for *S. suave* Walt. (See also *Cascara sagrada* for *Rhamnus purshiana* DC., p. 65.) Since Abrams' *Illustrated Flora of the Pacific States* and other floras and manuals are easily available for the area she covers, it is difficult to appreciate why we are burdened with nomenclature that is no longer common and is in some cases invalid. Her rendering of Indian names, while not reliable (*"Moon-num Moon-num"* for Warm Springs Sahaptin *wunmwunm*, p. 68), is superior to some efforts by non-linguists.

The publication does have merits, however, not the least of which is that most of the data are original. It thus contains research leads for specialists, even though any given fact may not be accurate.

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Reed College*

Sugarcane and Its Diseases. Claude W. Edgerton. 2nd Edition, Revised, 1958. Louisiana State University Press, Baton Rouge, La. x + 301 pp., 40 figs. $7.50.

The second edition of this book is for the most part a reprinting of the first, although new material has been added to several chapters to include recent research findings, and some of the discussions have been revised. Improvements include standard printing instead of offset, cloth binding rather than paper, and placing the illustrations in the text where reference to them occurs, instead of in a group at the back of the book, as in the first edition.

Part I has chapters on the History, Structure, Classification, Breeding and Varieties of Sugarcane, while Part II treats sugarcane diseases under the following chapter headings: Sugarcane Diseases: General; Rots of the Stalk Caused by Fungi; Smuts; Lesions and Spots on Leaves Caused by Fungi; Mildews; Multiple Bud and other Malformations; Bacterial Diseases; Root Rot, including various root failures; Various Blemishes, Injuries, and Minor Diseases; Parasitic Flowering Plants; and Virus Diseases. There are 40 text figures, 714 literature citations, and an index. Seven of the illustrations show the sugarcane plant and its anatomy, twenty-eight show symptoms or effects of diseases, and four show disease causal organisms.

The most extensively revised section is that on ratoon stunting disease, which is to be expected since in the interim between the two editions more research has been devoted to this relatively recently identified sugarcane disease than to any other. However, the statements on p. 250 regarding the succession of varieties in Louisiana are not up to date, and some recent published reports on the relation of this disease to decline of varieties are not referred to. In the discussion of heat therapy for control, the specially-designed, electrically-heated, hot-air ovens which are used on a large scale for this purpose in Louisiana are not mentioned.

Dr. Edgerton has the art of presenting technical subject matter in simple, clear language that is intelligible to the non-specialist, yet does not appear unduly simplified to the technologist. All sugarcane pathologists may not agree with all of the author's statements and interpretations, but such disagreement will be of concern primarily to specialists on certain diseases. Readers in some countries may feel that the space devoted to red rot

(32 pages), root rot (23 pages), and mosaic (20 pages), with which the author has had more experience in Louisiana, is disproportionate in comparison with that allotted to diseases that are of greater importance elsewhere, such as downy mildew (7 pages), chlorotic streak (5 pages), smut (5 pages), or leaf scald (7 pages). To some extent, however, these disparities reflect relative volume of published research on the different diseases.

This is the only publication that brings together in a single volume a summary and interpretation of the world literature on sugarcane diseases, and as such is an invaluable reference for research workers, teachers, extension specialists, and growers concerned with sugarcane production. The fact that the first edition was so soon out of print is evidence of its usefulness and an indication of the need for this second edition.

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The Higher Terpenoids. P. de Mayo. vi + 239 pp. Interscience Publishers, New York. 1959. $6.00.

This book is the third volume of a series edited by K. W. Bentley and entitled *The Chemistry of Natural Products.* It, as well as the previous volumes, is in many respects a unique contribution to the chemical literature. There has not been in the past a text designed to introduce the student to the intricacies of the chemistry of natural products. The spirit of excitement and suspense that characterizes the field has lain buried among the multitudes of data which necessarily accompany published experimental papers. The author of *The Higher Terpenoids* has shared his considerable experience with the reader by presenting a behind-the-scenes account of how some of the most complex chemical structures in nature have been elucidated.

About one-fourth of the book is concerned with the chemistry of diterpenoids, and the remainder, except for a short chapter on biogenetic relationships, deals with triterpenoid chemistry. The format is such that the text occupies the even-numbered pages with the odd-numbered pages being reserved for illustrating structural formulae. While this scheme may reduce printing costs, it has its disadvantages. Summing up the spaces left empty in the process of matching formulae with text, one finds that over an eighth of the book consists of blank pages. Happily, the quality of the remaining seven-eighths is more than sufficient to compensate for this.

The discussion of diterpenoids begins with a summary, shorn of all non-essential details, outlining the steps followed in determining the structures of several important resin acids. The systematic manner in which the author pieces together the structural evidence might make these problems appear deceptively simple were it not for his frequent mention of pitfalls which led temporarily to incorrect conclusions. Research on several compounds related to resin acids is described, and the methods used in studying some of the more complex diterpenoids, such as marrubiin, cafestol, and stevioside are discussed. It is regretable that an account is not given of the elegant investigations carried out on the very interesting (both structurally and physiologically) diterpenoid, gibberellic acid.

Examples of structural analyses among the triterpenoids are drawn from all families, beginning with the acyclic hydrocarbon squalene and including lanosterol and other sterols, onocerin, β-amyrin, α-amyrin, and a number of others. As in the case of the diterpenes, methods of determining the stereochemistry are generally included. Throughout the book the interrelationships of the compounds described are stressed at appropriate points.

The principal fault of the book is perhaps most glaring in the chapter dealing with biogenetic relationships. It stems from the inordinately long time that the manuscript remained in the hands of the publisher. Recent developments in isoprenoid biogenesis since *The Higher Terpenoids* went to press early in 1957 have caused this section to be very badly outdated. The same criticism can be aimed at certain other portions of the book as well.

A brief report is given of degradations carried out on compounds labeled specifically during biosynthesis from C^{14}-acetic acid units. In view of the increasing use being made of radioactive isotopes for biogenetic studies, it would perhaps have been worthwhile to elaborate on the techniques used in isolating specific carbon atoms from complex structures.

In general *The Higher Terpenoids* is likely to appeal to the novice as well as to the experienced natural products chemist. Its lucidly presented introduction to a little understood field will make it a welcome addition to the library of everyone interested in the chemistry of naturally occurring compounds.

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Subsistence Agriculture in Melanesia. Barrau, Jacques. Bernice P. Bishop Museum Bulletin 219: 1-111, 34 figs. 1959.

Dr. Barrau's monograph on the subsistence agriculture in Melanesia is a well-organized, well-written account of the traditional kind of agriculture carried out in the tropics and subtropics around the world. With minor changes parts might have been written about the subsistence agriculture of tropical America.

The report covers about a year and a half of field study in Melanesia, first in New Caledonia, progressing to Netherlands New Guinea, the Territory of Papua, the New Hebrides, the Solomon Islands, and ending in Fiji. Similar reports on surveys in Polynesia and Micronesia are to be expected in course of time.

There is a good chapter on *Melanesia and the Melanesians* which covers the climate, the vegetation, the natural regions, and man with his background and primitive economy. A good account of the subsistence economies and agricultural systems, divided according to the natural regions with each of these discussed in some detail, follows. The patterns of vegetable and animal foods are examined in detail. Vegetable foods are divided into plants which provide the staple subsistence foods and those which provide the supplementary subsistence foods. The account is especially good, for it indicates the relative importance of the kinds of foods used in Melanesia, which is certainly different from that in many other tropical areas of the world. Sources of animal foods, fish, wild game, and domestic animals are discussed. Except in a few areas food resources of animal origin are limited. Pigs are often the chief item of native wealth and prestige.

The concluding section of the monograph has to do with the problems of subsistence agriculture in the area. The agricultural systems and equipment, human nutrition, and possible solutions to the subsistence-agriculture problems are surveyed.

In summary Barrau makes the following statement, which seems to the present reviewer to be as apt for other underdeveloped tropical areas of the world as for Melanesia: "Improving the nutritional and financial resources of native peoples will serve no useful purpose if some attempt is not made to assist Melanesian society to adjust itself to this new way of life, and to the new economic era which is dawning. It would be a serious mistake to limit improvements to a few aspects of native activity. Modernization of Melanesian rural communities should form a part of coordinated programs for economic and social development. It is only one aspect of progress; and it may well prove ineffectual, at worst even dangerous, if it is not conceived in relation to the new society which will develop in Melanesia."

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Plant Pathology: An Advanced Treatise Volume I: The Diseased Plant. Ed. by J. G. Horsfall and A. E. Dimonds. 677 pp. Illus. Indexed. Academic Press, New York and London. 1959. $22.00.

This text is indeed an advanced treatise in the field of plant pathology designed for the creative worker and not for the beginning student. It is without doubt the most comprehensive, most scholarly discussion ever prepared in plant pathology. Knowing both editors personally, I cannot see how it could have been anything but that. Both editors have made outstanding contributions to their fields and continue to be active despite the pressure of many administrative and extra curricular assignments.

Horsfall and Dimond set the pattern of the book in the first chapter on *The Diseased Plant.* They are strong advocates of classifying diseases on the basis of pathological processes involved rather than on causal organisms. Six pathological processes are listed: *tissue is disintegrated; growth is affected; reproduction is affected; host is starved; water is deficient;* and *respiration is altered.*

In order to show the wide scope of subjects covered in this first volume, the follow-

ing titles and contributors are listed: *The Diseased Plant,* J. G. Horsfall and A. E. Dimond; *Scope and Contributions of Plant Pathology,* J. G. Ten Houten, Institute of Phytopathological Research, Wageningen, Holland; *History of Plant Pathology,* G. W. Keitt, University of Wisconsin; *How Sick is the Plant?* K. Starr Chester, Alton, Illinois; *Tissue is Disintegrated,* Akhtar Husain, Kanpur, India and Arthur Kelman, North Carolina State College; *Growth is Affected,* A. C. Braun, Rockefeller Institute, New York City; *Reproduction is Affected,* Antonio Ciccarone, Bari, Italy; *The Host is Starved,* C. Sempio, Perugia, Italy; *Water is Deficient,* D. Subramanian, and L. Sarawathi-Devi, Madras, India; *Alteration of the Respiratory Pattern in Infected Plants,* Ikuzo Uritani and Takashi Akazawa, Anjo, Aichi, Japan; *Histology of Defense in Plants,* S. Akai, Kyoto, Japan; *Physiology and Biochemistry of Defense,* Paul J. Allen, University of Wisconsin; *Hypersensitivity,* K. O. Müller, Canberra, Australia; *Predisposition,* C. E. Yarwood, University of California; and *Therapy,* F. L. Howard, University of Rhode Island and J. G. Horsfall.

Among the chapters which appealed most to me were *The Diseased Plant, Physiology and Biochemistry of Defense,* and *Therapy.* Perhaps the most interesting of all to a practicing plant pathologist like myself is the last mentioned. Howard and Horsfall do admit, however, that this phase of plant disease control is still in the adolescent stage.

One minor editorial inconsistency was noted. Some of the authors referred the root-knot nematode (I prefer, nema) to the genus *Heterodera,* others referred it to the genus *Meloidogyne* where it now rightfully belongs.

It is to be hoped that the two volumes to follow in this series will be as good and as comprehensive as Volume I.

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The Application of Genetics to Cotton Improvement. Sir Joseph Hutchinson. New York: Cambridge University Press. 1959. viii + 87 pp. $3.00.

The great debt owed by cotton geneticists to Sir Joseph Hutchinson, now Draper's Professor of Agriculture in the University of Cambridge, for his sustained efforts over many years to describe the story of cotton, is greatly increased by this book. This story is not only one of the most interesting of the cultivated plant histories, but it is also perhaps one of the most complex and most difficult to simplify. Sir Joseph has achieved this aim with great clarity in this book, which makes it essential reading for all those interested in economic plants in general, as well as in cotton. The book is based on lectures delivered by the author in the summer of 1951 at the North Carolina State College, Raleigh. At that time, Sir Joseph was still Director of the Cotton Research Station at Namulonge, Uganda, and the book also includes material based on work done at Namulonge in the years up to 1954 and subsequently.

The previous contribution of Sir Joseph Hutchinson, in a book, to the evolutionary aspects of *Gossypium* studies and cotton breeding occurred in 1947, with the publication jointly with R. A. Silow and S. G. Stephens of "The Evolution of Gossypium." The present book follows the same general pattern and incorporates much of the important work on cotton published since that date. The first four chapters deal with the wild relatives of the cultivated cottons, problems of evolution, and the origin, domestication and spread of the Old and New World cultivated cottons. In these sections, Sir Joseph Hutchinson reiterates his new hypothesis first announced in 1954 that "a form of one of the Asiatic cottons, the South African *G. herbaceum* race *africanum* is truly wild, and is the modern representative of the wild ancestors of all diploid cottons." He places the probable area of domestication not in southern Africa, however, or in the African continent, but in southern Arabia. This hypothesis, although not universally accepted, has served to stimulate much new thought and research on the evolutionary problems of the genus and on the domestication of the cultivated forms, particularly in relation to the African continent. In discussing the spread of New World cottons, Sir Joseph suggests that the cotton from Huaca Prieta in Peru, where the oldest cottons so far discovered in the New World were excavated in 1946 by J. B. Bird, is a form of *G. barbadense.*

The last two sections of the book are

entitled "Breeding Systems" and "The Improvement of African Cotton," and contain a brief but important contribution to the history of cotton breeding and the application of genetics to agriculture. The fundamental genetical concepts described were first established on a sound basis mainly by S. C. Harland and his associates, of whom Sir Joseph was one, during the years of intensive research carried out at the Cotton Station of the Empire Cotton Growing Corporation in Trinidad, British West Indies. These concepts reflected important advances made in the empirical analysis of selection and its role in plant populations. One of the most direct consequences in cotton breeding was the recognition of the importance of genetic variance in securing improved cotton, and hence of the importance of "primary selection." Hutchinson in India, Hutchinson and Manning in Uganda, and Harland in Peru, among others, later successfully applied these methods to cotton breeding problems. The new approach, in essence, marked a departure from pure line selection, which was replaced by mass pedigree selection and appropriate statistical analysis. In this way a system of gene frequencies is arrived at, which manifests the character under selection at an improved level by the continuous elimination of unfavorable alleles. In appropriate circumstances, both a high degree of flexibility and a sufficient degree of uniformity are attainable by this means. This is well illustrated by such cotton varieties selected by this method as 'SNA Tanguis' of Peru and 'Upland B52' of Uganda. However, the success that might be obtained in cotton breeding by the use of selection index techniques and mass pedigree is greatly dependent on the degree of variability found in the gene pool from which the initial selections are made. Sir Joseph examines this problem for cotton in East Africa and describes a technique whereby a variable source for further varietal improvement might be created for future use. But the best use of such breeding stocks can come only by enlisting the plant physiologist to define the environment where the new varieties would be grown. Hence, Sir Joseph, who begins his book with the statement that by "nature I am a practical man," ends it with a practical look at the future: "In the developing partnership between geneticists and physiologists lies the hope of understanding the nature of our crop plants, and of directing the improvement of crop production."

G. EDWARD NICHOLSON

Textes Grecs Inédits Relatifs aux Plantes. Margaret H. Thomson. 177 pp. Société D'Édition "Les Belles Lettres". Blvd. Raspail, 95, Paris, France. 1955.

A rare combination of talents is represented in this work by Professor Thomson, formerly of McMaster University, now on the staff of Hill Park Secondary School, Hamilton, Ontario. Linguistic facility in Greek coupled with botanical proficiency has resulted in a scholarly scientific study which began under the tutelage of Professor Alphonse Dain of The Sorbonne. This represents only a small portion of a five-year investigation wherein some 500 medieval Greek manuscripts relating to plants were located in a search of libraries in England, Italy, Holland, and other countries. An earlier account was published in the *Revue des Études Grecques* (**46**: 334-348, 1933).

Although published in 1955, the present study was apparently printed in a limited edition and appears to have been largely overlooked. It is an assemblage of eleven texts chosen as representative of the collection, with the original Greek text on the right facing page and the translation (for all except two lexicons) in the French language on the opposing page, together with a critical commentary. The texts include a 15th century text on *La Cueillette du Poivre* taken from a codex including the works of Aratus, Nicander, and Theocritus; two texts on grafting (12th century and early 15th century) embodying edited material taken from a work of Cassianus Bassus (6th century A. D. writer); a medico-astrological text of the late 15th century; a medico-magic text of the late 14th century; a 15th century pharmaceutical manuscript listing the uses of 26 plants taken from the works of Aëtius (5th century A. D.); another pharmaceutical text of the 16th century from originals of about the 6th century; a dietary manual of the 16th century possibly originally prepared for the use of the physicians of the hospital of Pantocrator (late 7th century); and three lexicons, with comments only on a fourth, that of Nicomedes. The lexicons

of the Byzantine epoch include one of the 15th century listing Greek synonyms and including the names of 150 plants (not translated into French); a 15th century lexicon providing plant names or identifications in ancient and modern Greek, as well as in Latin, Arabic, and Persian, which is here critically edited without translation into French—a list of some 418 items; and a 16th century manuscript listing 33 plants and their habitats which has been provided with a French translation.

In the splendid introduction backed by a wealth of source material we learn that the *De Plantis*—long attributed to Aristotle, following the studies of Meyer and Bouyges—is estimated to have been composed in the 1st century B. C. by Nicolas Damascenus. One is again made to realize quite forcefully the heritage of fine manuscript material which still awaits this type of critical study.

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Food Plants of the South Sea Islands. Emile Massal & Jacques Barrau. South Pacific Commission (Nouméa, New Caledonia) Technical Paper No. **94**: iv + 52. 1956. Six shillings sterling.

This is a useful account of the food plants of the South Sea Islands, including New Guinea. The range of food plants that it is possible to grow in the "south seas," from a fertile mountain valley surrounded by snow mountains in New Guinea to a Micronesian coral island is great.

The report is divided into three sections: I: *The South Sea Islanders and Their Food Plants;* II: *The Staple Food Plants;* III: *The Supplementary Food Plants.*

To the botanist working with the economic plants of tropical America several of the plants given as staple food are unfamiliar or are rarely encountered. The principal staple foods of the "south seas" are root crops—the taros and taro-like plants, polynesian arrowroot, the yams, cassava and sweet potatoes. Other staples are sago, bananas, and breadfruit. Cassava, sweet potatoes, and bananas are staple food plants in tropical America but the others are of relatively little importance when compared to the staple "seed foods," beans, maize, sorghum, and rice. These kinds of "seed foods" are mentioned by the authors but are of relatively little importance in the "south seas" area. A great many "supplementary food plants" are mentioned. Some of these are well-known and important around the world (coconuts, beans, cereals) while others are unusual or unknown except in the "south seas" region.

There are more than one hundred illustrations in the work—from photographs and pen sketches. These are useful in recognizing and understanding the food plants of the "south seas," especially the important ones of the Araceae. There are interesting comments through the work on the history and culture of these food plants in the "south seas" region.

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